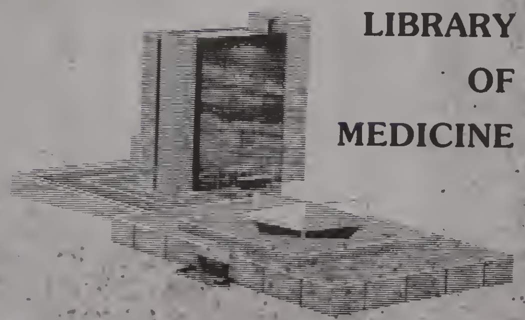
U.S. NATIONAL LIBRARY OF MEDICINE



98

A New and Complete DICTIONARY OF Arts and Sciences;

Including the latest Improvement and Discovery

And the Present State of every branch of Human Knowledge.

BY G. GREGORY. D.D.

Domestic Chaplain to the Bishop of Landaff. Author of the Economy of Nature. &c. &c.

IN THREE VOLUMES.

Vol. 2.

PHILADELPHIA.

PUBLISHED BY ISAAC PEIRCE,

Nº. 316 Market Street,

1816.

A

DICTIONARY

OF

ARTS AND SCIENCES.

BY G. GREGORY, D. D.

DOCTOR IN PHILOSOPHY AND THE ARTS, AND HONORARY MEMBER OF THE IMPERIAL UNIVERSITY OF WILNA; MEMBER OF THE MANCHESTER AND NEWCASTLE LITERARY AND PHILOSOPHICAL SOCIETIES; HONORARY MEMBER OF THE BOARD OF AGRICULTURE; DOMESTIC CHAPLAIN TO THE LORD BISHOP OF LANDAFF; AUTHOR OF ESSAYS HISTORICAL AND MORAL, THE ECONOMY OF NATURE, &c. &c.

IN THREE VOLUMES.

VOL. II.

FIRST AMERICAN, FROM THE SECOND LONDON EDITION,

CONSIDERABLY IMPROVED AND AUGMENTED.

PHILADELPHIA:

PUBLISHED BY ISAAC PEIRCE, No. 316 MARKET STREET.

SOLD ALSO BY COALE AND MAXWELL, BALTIMORE, AND JAMES F. SHORES, PORTSMOUTH, N. H.

DENNIS HEARTT, PRINTER.

1816.

A

DICTIONARY

OF

ARTS AND SCIENCES.

ETHULIA, a genus of the class and order syngenesia polygamia æqualis. The receptacle is naked; down none. There are six species, chiefly annuals of the East Indies.

ETHUSA, fool's parsley. See ÆTHUSA.

ETNA. See VOLCANO.

ETYMOLOGY, that part of grammar which considers and explains the origin and derivation of words, in order to arrive at their first and primary signification, whence Quintilian calls it *originatio*.

The best treatise on the etymology of English words, and for the ascertaining of their force and usage, is unquestionably the Epea Pteroenta of Mr. Horne Tooke, already quoted in this work.

EVACUANTS. See MATERIA MEDICA.

EVANTES, in antiquity, the priestesses of Bacchus, thus called, because in celebrating the orgia, they ran about as if distracted, crying, *evan, evan, ohe' evan.*

EVAPORATION, in chemistry, the setting a liquor in a gentle heat or in the air, to discharge its superfluous humidity, reduce it to a proper consistence, or obtain its dry remainder.

Evaporation, though generally considered as the effect of the heat and motion of the air, may be produced by a different cause. Fluids lose more by evaporation in the severest frost than when the air is moderately warm. Thus, in the great frost of 1708, it was found that the greater the cold the more considerable the evaporation. Ice itself loses much by evaporation.

EVAPORATION, in natural philosophy, is the conversion of water into vapour, which in consequence of becoming lighter than the atmosphere, is raised considerably above the surface of the earth, and afterwards by a partial condensation forms clouds. It differs from exhalation, which is properly a dispersion of dry particles from a body.

We are indebted to the experiments of Saussure and Deluc for much of our knowledge of the qualities of vapour. It is an elastic invisible fluid like common air, but lighter; being to common air of the same elasticity, according to Saussure, as 10 to 14, or, according to Kirwan, as 10 to 12.

When water is heated to 212°, it boils, and is rapidly converted into steam; and the same change takes place in much lower temperatures; but in that case the evaporation is lower, and the elasticity of the steam is smaller. As a very considerable proportion of the earth's surface is covered with water, and as this water is constantly evaporating and mixing with the atmosphere in the state of vapour, a precise determination of the rate of evaporation must be of very great importance in meteorology. Accordingly, many experiments have been made to determine the point by different philosophers. No person has succeeded so completely as Mr. Dalton; but many curious particulars had been previously ascertained by the labours of Richman, Lambert, Wallerius, Leidenfrost, Watson, Saussure, Deluc, Kirwan, and others.

1. The evaporation is confined entirely to the surface of the water: hence it is in all cases proportional to the surface of the water exposed to the atmosphere. Much more vapour of course rises in maritime countries, or those interspersed with lakes, than in inland countries.

2. Much more vapour rises during hot weather than during cold: hence the quantity evaporated depends in some measure upon temperature. The precise law has been happily discovered by Mr. Dalton. This philosopher took a cylindrical vessel of tin, whose diameter was $3\frac{1}{4}$ inches, and its depth $2\frac{1}{2}$ inches, filled it with water, and kept it just boiling for some time. The loss of weight in the minute was 30 grains, when the experiment was made in a close room without any draught of air; 35 grains when the vessel was placed over fire in the usual fire-place, there being a moderate draught of air, and the room close; 40 with a brisker fire and a stronger draught; and when the draught was very strong, he supposes the evaporation might amount to 60 grains in the minute. At the temperature of 180°, the quantity evaporated was one half of what was lost at 212°.

At 164° it was $\frac{1}{3}$ of that at 212°.

	152	$\frac{1}{4}$
	144	$\frac{1}{5}$
	138	$\frac{1}{6}$

And in general the quantity evaporated from a given surface of water per minute at any temperature is to the quantity evaporated from the same surface at 212°, as the force of vapour at the first temperature is to the force of vapour at 212°. Hence, in order to discover the quantity which will be lost by evaporation from water of a given temperature, we have only to ascertain the force of vapour at that temperature. Hence we see that the presence of atmospheric air obstructs the evaporation of water; but this evaporation is overcome in proportion to the force of the vapour. Mr. Dalton ascribes this obstruction to the vis inertiæ of air.

3. The quantity of vapour which rises from water, even when the temperature is the same, varies according to circumstances. It is least of all in calm weather, greater when a breeze blows, and greatest of all with a strong wind. The following table, drawn up by Mr. Dalton, shows the quantity of vapour raised from a circular surface of six inches in diameter in atmospheric temperatures. The first column expresses the temperature; the second the corresponding force of vapour; the other three columns give the number of grains of water that would be evaporated from a surface of six inches in diameter in the respective temperatures, on the supposition of there being previously no aqueous vapour in the atmosphere. These columns present the extremes and the mean of evaporation likely to be noticed, or nearly such; for the first is calculated upon the supposition of 35 grains loss per minute from the vessel of $3\frac{1}{2}$ inches in diameter; the second 45, and the third 55 grains per minute.

Temperature.	Force of vapour in inches.	Evaporating force in grains		
212°	30	120	154	189
20	.129	.52	[illegible]	[illegible]
21	.134	.54	.69	.85
22	.139	.56	.71	.88
23	.144	.58	.73	.91
24	.150	.60	.77	.94
25	.156	.62	.79	.97
26	.162	.65	.82	1.02
27	.168	.67	.86	1.06
28	.174	.70	.90	1.10
29	.180	.72	.93	1.13
30	.186	.74	.95	1.17
31	.193	.77	.99	1.21
32	.200	.80	1.03	1.26
33	.207	.83	1.07	1.30
34	.214	.86	1.11	1.35
35	.221	.89	1.14	1.39
36	.229	.92	1.18	1.45
37	.237	.95	1.22	1.49
38	.245	.98	1.26	1.54
39	.254	1.02	1.31	1.60
40	.263	1.05	1.35	1.65
41	.273	1.09	1.40	1.71
42	.283	1.13	1.45	1.78
43	.294	1.18	1.51	1.85
44	.305	1.22	1.57	1.92
45	.316	[illegible]	1.62	1.99
46	.327	1.31	1.68	2.06
47	.339	1.36	1.75	2.13
48	.351	1.40	1.80	2.20
49	.363	1.45	1.86	2.28
50	.375	1.50	1.92	2.36
51	.388	1.55	1.99	2.44
52	.401	1.60	2.06	2.51
53	.415	1.66	2.13	2.61
54	.429	1.71	2.20	2.69
55	.443	1.77	2.28	2.78
56	.458	1.83	2.35	2.88
57	.474	1.90	2.43	2.98
58	.490	1.96	2.52	3.08
59	.507	2.03	2.61	3.19
60	.524	2.10	2.70	3.30
61	.542	2.17	2.79	3.41
62	.560	2.24	2.88	3.52
63	.578	2.31	2.97	3.63
64	.597	2.39	3.07	3.76
65	.616	2.46	3.16	3.87
66	.635	2.54	3.27	3.99
67	.655	2.62	3.37	4.12
68	.676	2.70	3.47	4.24
69	.698	2.79	3.59	4.38
70	.721	2.88	3.70	4.53
71	.745	2.98	3.83	4.68
72	.770	3.08	3.96	4.84
73	.796	3.18	4.09	5.00
74	.823	3.29	4.23	5.17
75	.851	3.40	4.37	5.34
76	.880	3.52	4.52	5.53
77	.910	3.65	4.68	5.72
78	.940	3.76	4.83	5.91
79	.971	3.88	4.99	6.10
80	1.00	4.00	5.14	6.29
81	1.04	4.16	5.35	6.54
82	1.07	4.28	5.50	6.73
83	1.10	4.40	5.66	6.91
84	1.14	4.56	5.86	7.17
85	1.17	4.68	6.07	7.46

4. Such is the quantity of vapour which would rise in different circumstances, on the supposition that no vapour existed in the atmosphere. But this is a supposition which can never be admitted, as the atmosphere is in no case totally free from vapour. Now when we wish to ascertain the rate at which evaporation is going on, we have only to find the force of the vapour already in the atmosphere, and subtract it from the force of vapour at the given temperature: the remainder gives us the actual force of evaporation; from which, by the table, we readily find the rate of evaporation. Thus, suppose we wish to know the rate of evaporation at the temperature 59°. From the table we see that the force of vapour at 59° is 0.5, or $\frac{1}{60}$ its force at 212°. Suppose we find by trials that the force of the vapour already existing in the atmosphere is 0.25, or the half of $\frac{1}{60}$. To ascertain the rate of evaporation, we must subtract the 0.25 from 0.5; the remainder 0.25 gives us the force of evaporation required; which is precisely one half of what it would be if no vapour had previously existed in the atmosphere.

By the table we see that on that supposition a surface of six inches diameter would lose one grain by evaporation per minute, instead of two grains, which would have been converted into vapour if no vapour had previously existed in the atmosphere. If the force of the vapour in the atmosphere had amounted to 0.5, which is equal to the force of vapour at the temperature of 59°, in that case no vapour whatever would rise from the water; and if the force of the vapour already in the atmosphere exceeded 0.5, instead of evaporation, moisture would be deposited on the surface of the water.

These general observations, for all of which we are indebted to Mr. Dalton, account in a satisfactory manner for all the anomalies which had puzzled preceding philosophers; and include under them all the less general laws which they had discovered. We must consider the discoveries of Mr. Dalton as the most important additions made to the science of meteorology for these many years.

5. As the force of the vapour actually in the atmosphere is seldom equal to the force of vapour of the temperature of the atmosphere, evaporation, with a few exceptions, may be considered as constantly going on.

Various attempts have been made to ascertain the quantity evaporated in the course of a year; but the difficulty of the problem is so great, that we can expect only an approximation towards a solution. From the experiments of Dr. Dobson of Liverpool in the years 1772, 1773, 1774, and 1775, it appears that the mean annual evaporation from the surface of water amounted to 36.78 inches. The proportion for every month was the following:

	Inches.		Inches.
January -	1.50	July - -	5.11
February -	1.77	August - -	5.01
March -	2.64	September -	3.18
April - -	3.30	October -	2.51
May - -	4.34	November -	1.51
June - -	4.41	December -	1.49

Mr. Dalton found the evaporation from the surface of water in one of the driest and hotest days of summer rather more than 0.2 of an inch.

If we believe Mr. Williams, the evaporation from the surface of land covered with trees and other vegetables is one-third greater than from the surface of water; but this has not been confirmed by other philosophers. From his experiments it appears, that in Bradford in New England the evaporation, during 1772, amounted to 42.65 inches. But from the way that his experiments were conducted, the amount was probably too great.

From an experiment of Dr. Watson, made on the 2d of June 1779, after a month's drought, it appears, that the evaporation from a square inch of a grass plot amounted to 12 grains in an hour, or 8.8 grains in 24 hours, which is 0.061 of an inch. In another experiment, after there had been no rain for a week, the heat of the earth being 110°, the evaporation was found almost twice as great, or = 0.108 of an inch in the day. The mean of these two experiments is 0.084 inches, amounting for the whole of June to 2.62 inches. If we suppose this to bear the same proportion to the whole year that the evaporation in Dr. Dobson's experiments for June do to the annual evaporation, we shall obtain an annual evaporation, amounting to about 22 inches. This is much smaller than that obtained by Mr. Williams. But Dr. Watson's method was not susceptible of precision. He collected the vapour raised on the inside of a drinking-glass; but it was impossible that the glass could condense much more than one half of what did rise, or would have been raised in other circumstances. But then the experiments were made in the hottest part of the day, when much more vapour is raised than during any other part of it.

The most exact set of experiments on the evaporation from the earth was made by Mr. Dalton and Mr. Hoyle, during 1796, and the two succeeding years. The method which they adopted was this: Having got a cylindrical vessel of tinned iron, ten inches in diameter, and three feet deep, there were inserted into it two pipes turned downwards for the water to run off into bottles: the one pipe was near the bottom of the vessel, the other was an inch from the top. The vessel was filled up for a few inches with gravel and sand, and all the rest with good fresh soil. It was then put into a hole in the ground, and the space around filled up with earth, except on one side, for the convenience of putting bottles to the two pipes; then some water was poured on to sadden the earth, and as much of it as would was suffered to run through without notice, by which the earth might be considered as saturated with water. For some weeks the soil was kept above the level of the upper pipe, but laterly it was constantly a little below it, which precluded any water running off through it. For the first year the soil at top was bare; but for the two last years it was covered with grass the same as any green field. Things being thus circumstanced, a regular register was kept of the quantity of rain water that ran off from the surface of the earth through the upper pipe (whilst that took place), and also of the quantity of that which sunk down through the three feet of earth, and ran out through the lower pipe. A rain-guage of the same diameter was kept close by to find the quantity of rain for any corresponding time. The weight of the water which ran through the pipes being subtracted from the water in the rain-guage, the remainder was considered as the weight of the water evaporated from the earth in the vessel. The following table exhibits the mean annual result of these experiments.

	Water through the two pipes. 1796. Inch.	1797. Inch.	1798. Inch.	Mean. Inch.	Mean Rain. Inch.	Mean Evap. Inch.
January	1.897—	.680—	1.774+	1.450+	2.458	1 008
February	1.778—	.918—	1.122	1.273	1 801	.528
March	.431—	.070—	.335	.279	.902	.623
April	.220—	.295—	.180	.232	1.717	1.485
May	2.027—	2.443+	.010	1.493+	4.177	2 684
June	.171—	.726	——	.299	2.483	2.184
July	.153—	.025	——	059	4.15,	4.095
August	——	——	.504	168	3 554	3 386
September	——	.976	——	.325	3.279	2.954
October	——	.680	——	227	2.899	2.672
November	——	1.044	1.594	.879	2.934	2.055
December	.200	3.077	1.878+	1.718+	3.202	..484
	6.877—	10 934—	7.379	8.402	33 560	25 158
Rain	30.629—	38.791—	31.259			
Evap.	23.725—	27.857—	23.862			

From these experiments it appears that the quantity of vapour raised annually at Manchester is about 25 inches. If to this we add five inches for the dew with Mr. Dalton, it will make the annual evaporation 30 inches. Now, if we consider the situation of England, and the greater quantity of vapour raised from water, it will not surely be considered as too great an allowance if we estimate the mean annual evaporation over the whole surface of the globe at 35 inches. Now, 35 inches from every square inch on the superficies of the globe make 94,450 cubic miles, equal to the water annually evaporated over the whole globe.

Was this prodigious mass of water all to subsist in the atmosphere at once, it would increase its mass by about a twelfth, and raise the barometer nearly three inches. But this never happens; no day passes without rain in some part of the earth, so that part of the evaporated water is constantly precipitated again. Indeed it would be impossible for the whole of the evaporated water to subsist in the atmosphere at once, at least in the state of vapour.

EUCALYPTUS, a genus of the hexandria monogynia class and order. The calyx is superior, permanent, truncate before flowering, covered with an hemispherical deciduous lid. Corolla, none; capsule four-celled, opening at top, inclosing many seeds. There are two species, lofty trees of New Holland; called also the red-gum tree, from a gummy matter, in which one of them, the resinifera, abounds. A single tree will, on being tapped, afford more than 60 gallons of juice, which when dried becomes a powerfully astringent gum resin, resembling that known in the shops by the name of kino, and found eminently efficacious in dysenteries, &c. Water dissolves of it only one-sixth part, but it dissolves abundantly in spirit of wine, to which it gives a blood-red colour.

EUCLEA, a genus of the diœcia dodecandria class and order. In both male and female the calyx is four or five-toothed; the corolla four or five-parted; the male stamina 12 to 15. In the female, the germ is superior; the styles two; berry two-celled. There is one species, a branching tree of the Cape.

EUCOMIS, a genus of the class and order hexandria monogynia. The calyx is inferior, six-parted, permanent, spreading; filaments united at the base into a nectary growing to the corolla. There are four species, plants of the Cape.

EUDIOMETER, an instrument for ascertaining the purity of the atmospherical air, or the quantity of oxygenous gas contained in it, chiefly by means of its diminution on a mixture with nitrous acid, or some similar substance.

After the composition of the atmosphere was known to philosophers, it was taken for granted that the proportion of its oxygen varied in different times and in different places; and that upon this variation the purity or noxious qualities of air depended. Hence it became an object of the greatest importance to be in possession of a method of determining readily the quantity of oxygen in a given portion of air. Accordingly, various methods were proposed, all of them depending upon the property which bodies possess of absorbing the oxygen of the air without acting upon its azote. These bodies were mixed with a certain known quantity of atmospheric air, in graduated glass vessels inverted over water, and the proportion of oxygen was determined by the diminution of bulk. These instruments received the name of eudiometers, because they were considered as measures of the purity of air. The eudiometers proposed by different chemists may be reduced to five.

1. The first eudiometer was made in consequence of Dr. Priestley's discovery, that when nitrous gas is mixed with air over water, the bulk of the mixture diminishes rapidly, in consequence of the combination of the gas with the oxygen of the air, and the absorption of the nitric acid thus formed by the water. When nitrous gas is mixed with azotic gas, no diminution at all takes place. When it is mixed with oxygen gas in proper proportions, the absorption is complete. Hence it is evident, that in all cases of a mixture of these two gases, the diminution will be proportional to the quantity of the oxygen. Of course it will indicate the proportion of oxygen in air; and by mixing it with different portions of air, it will indicate the different quantities of oxygen which they contain, provided the component parts of air are susceptible of variation. Dr. Priestley's method was, to mix together equal bulks of air and nitrous gas in a low jar, and then to transfer the mixture into a narrow graduated glass tube about three feet long, in order to measure the diminution of bulk. He expressed this diminution by the number of hundredth parts remaining. Thus, suppose he had mixed together equal parts of nitrous gas and air, the sum total of this mixture was 200 (or 2.00): suppose the residuum when measured in the graduated tube to amount to 104 (or 1.04), and of course that 96 parts of the whole had disappeared, he denoted the purity of the air thus tried by 104. A more convenient instrument was invented by Dr. Falconer of Bath; and Fontana greatly improved this method of measuring the purity of air. A description of his eudiometer was published by Ingenhouz, in the first volume of his Experiments: it was still farther improved by Mr. Cavendish in 1783; and Humboldt has lately made a very laborious set of experiments in order to bring it to a state of complete accuracy. But after all the exertions of these philosophers, the method of analysing air by means of nitrous gas is liable to so many anomalies, that it cannot be depended on.

Priestley and Fontana have proved, that the way of mixing the two airs occasions a great difference in the result: the figure of the vessels is equally important, and so is the water over which the mixture is made. And even when all these things are the same, the impurity of the nitrous gas may occasion the most enormous differences in the results.

Humboldt has shown that the nitrous gas ought to be prepared by means of nitric acid of the density 1.170; when a much stronger or weaker acid is employed, the gas produced is always contaminated with a great proportion of azotic gas. He has pointed out the solution of sulphat of iron as proper to ascertain the purity of the nitrous gas employed, by absorbing the nitrous gas, and leaving the azotic gas or other foreign gases. He has shown that when nitrous gas of the same degree of purity is made to mix very slowly with air, the vessel being carefully agitated during the mixture, the results, provided the experiment is performed with address, corres-

pond with each other. And he has made it probable, that when equal quantities of air and nitrous gas, so pure as to contain only about 0.1 of azotic gas mixed with it, are agitated together slowly over water, the diminution divided by 3.55, gives the quantity of oxygen contained in the air examined. But notwithstanding the ingenuity of his experiments, the anomalies attending this method are still so great as not to render it susceptible of accuracy. For that reason it is unnecessary to give a particular description of the different eudiometers invented to ascertain the purity of air by means of nitrous gas. The result of the numerous experiments which have been made with nitrous gas is, that the proportion of oxygen in atmospheric air varies in different places and at different times. The minimum is about 0.22, the maximum about 0.30; consequently if this method of analysing air is to be depended on, we must consider that fluid not as a permanent chemical compound, but as a body subjected to all the variations to which accidental mixtures are liable.

2. The second kind of eudiometer was proposed by Volta. The substance employed by that philosopher to separate the oxygen from the air was hydrogen gas. His method was, to mix given proportions of the air to be examined and hydrogen gas in a graduated glass tube; to fire the mixture by an electric spark; and to judge of the purity of the air by the bulk of the residuum. But this method is not susceptible of even so great a degree of accuracy as the preceding, when the object is to ascertain the precise quantity of oxygen gas in a given bulk of air. For if too little hydrogen gas is mixed with the air, not only the whole of the oxygen will not be abstracted, but a portion of the azote will disappear in consequence of the formation of nitric acid. On the other hand, if too much hydrogen is added, part of it will remain after the firing of the mixture, and increase the bulk of the residuum. Volta's eudiometer, then, though it may have its uses, is scarcely susceptible of giving us the analysis of air.

3. For the third kind of eudiometer, we are indebted to Scheele. It is merely a graduated glass vessel, containing a given quantity of air exposed to newly prepared liquid alkaline or earthy sulphurets, or to a mixture of iron-filings and sulphur, formed into a paste with water. These substances absorb the whole of the oxygen of the air, which converts a portion of the sulphur into an acid. The oxygen contained in the air thus examined, is judged of by the diminution of bulk which the air has undergone. This method is not only exceedingly simple, but it requires very little address, and yet is susceptible of as great accuracy as any other whatever. The only objection to which it is liable is its slowness; for when the quantity of air operated on is considerable, several days elapse before the diminution has reached its maximum.

But this objection has been completely obviated by M. De Marti, who has brought Scheele's eudiometer to a state of perfection. He found that a mixture of iron-filings and sulphur does not answer well, because it emits a small quantity of hydrogen gas, evolved by the action of the sulphuric acid formed by the absorption of the oxygen of the air upon the iron; but the hydrogureted sulphurets, formed by boiling together sulphur and liquid potass or lime-water, answered the purpose perfectly. These substances, indeed, when newly prepared, have the property of absorbing a small portion of azotic gas; but they lose this property when saturated with that gas, which is easily effected by agitating them for a few minutes with a small portion of atmospheric air. His apparatus is merely a glass tube, ten inches long, and rather less than half an inch in diameter, open at one end, and hermetically sealed at the other. The close end is divided into 100 equal parts, having an interval of one line between each division. The use of this tube is to measure the portion of air to be employed in the experiment. The tube is filled with water; and by allowing the water to run out gradually while the tube is inverted, and the open end kept shut with the finger, the graduated part is exactly filled with air. These hundredth parts of air are introduced into a glass bottle filled with liquid sulphuret of lime previously saturated with azotic gas, and capable of holding from two to four times the bulk of the air introduced. The bottle is then to be corked with a ground glass stopper, and agitated for five minutes. After this the cork is to be withdrawn while the mouth of the phial is under water; and for the greater security, it may be corked and agitated again. After this, the air is to be again transferred to the graduated glass tube, in order to ascertain the diminution of its bulk.

Air, examined by this process, suffers precisely the same diminution in whatever circumstances the experiments are made: no variation is observed whether the wind is high or low, or from what quarter soever it blows; whether the air tried is moist or dry, hot or cold; whether the barometer is high or low. Neither the season of the year, nor the situation of the place, its vicinity to the sea, to marshes, or to mountains, makes any difference. M. De Marti found the diminution always between 0.21 and 0.23. Hence we may conclude that air is composed of

0.78 azotic gas.
0.22 oxygen gas.
————
1.00

Scheele indeed found, that the absorption amounted to 0.27; but that was because he neglected to saturate his sulphuret with azotic gas; for when the portion of azotic gas which must have been absorbed, and which has been indicated by De Marti, is subtracted, the portion of oxygen in air, as indicated by his experiments, is reduced very nearly to 0.22. The trifling variations perceptible in his experiments were no doubt owing to the quantities of the mixture of sulphur and iron, by which he abstracted the oxygen, not being exactly the same at different times; the consequence of which would be, an unequal absorption of azotic gas.

4. In the fourth kind of eudiometer, the abstraction of the oxygen of air is accomplished by means of phosphorus. This eudiometer was first proposed by Achard. It was considerably improved by Reboul, and by Seguin and Lavoisier; but Berthollet has lately brought it to a state of perfection, as it is equally simple with the eudiometer of De Marti, and scarcely inferior to it in precision.

Instead of the rapid combustion of phosphorus, this last philosopher has substituted its spontaneous combustion, which absorbs the oxygen of air completely; and

when the quantity of air operated on is small, the process is over in a short time. The whole apparatus consists in a narrow graduated tube of glass containing the air to be examined, into which is introduced a cylinder of phosphorus fixed upon a glass rod, while the tube stands inverted over water. The phosphorus should be so long as to traverse nearly the whole of the air. Immediately white vapours rise from the phosphorus and fill the tube. These continue till the whole of the oxygen combines with phosphorus. They consist of phosphorus acid, which falls by its weight to the bottom of the vessel, and is absorbed by the water. The residuum is merely the azotic gas of the air, holding a portion of phosphorous in solution. Berthollet has ascertained, that by this foreign body its bulk is increased one-fortieth part. Consequently, the bulk of the residuum, diminished by $\frac{1}{40}$, gives us the bulk of the azotic gas of the air examined; which bulk, subtracted from the original mass of air, gives us the proportion of oxygen gas contained in it.

All the different experiments which have been made by means of this eudiometer, agree precisely in their result, and indicate that the proportions of the ingredients of air are always the same, namely, about 0.22 parts of oxygen gas, and 0.78 of azotic gas. Berthollet found these proportions in Egypt and in France, and Dr. Thompson found them constantly in Edinburgh in all the different seasons of the year. Thus we see that the analysis of air by means of phosphorus, agrees precisely with its analysis by means of hydroguretted sulphurets.

5. The fifth eudiometer has been lately proposed by Mr. Davy. In it the substance used to absorb the oxygen from air is a solution of sulphat or muriat of iron in water, and impregnated with nitrous gas. A small graduated glass tube, filled with the air to be examined, is plunged into the nitrous solution, and moved a little backwards and forwards. The whole of the oxygen is absorbed in a few minutes. The state of greatest absorption ought to be marked, as the mixture afterwards emits a little gas which would alter the result. By means of this and the two preceding eudiometers, Mr. Davy examined the air at Bristol, and found it always to contain about 0.21 of oxygen. Air sent to Dr. Beddoes from the coast of Guinea gave exactly the same result. This eudiometer, then, corresponds exactly with the two last.

In all these different methods of analysing air, it is necessary to operate on air of a determinate density, and to take care that the residuum is neither more condensed nor dilated than the air was when first operated on. If these things are not attended to, no dependance whatever can be placed upon the result of the experiments, how carefully soever they may have been performed. Now there are three things which alter the volume of air and other elastic fluids: 1. A change in the height of the barometer. 2. An increase or diminution of their quantity; the vessel in which they are contained remaining the same, and standing in the same quantity of water or mercury. 3. A change in the temperature of the air.

EVERGREEN, in gardening, a species of perennials which continue their verdure, leaves, &c. all the year: such are hollies, phillyrias, laurustinuses, bays, pines, firs, and cedars of Lebanon. See GARDENING.

EVES-DROPPERS, are such as stand under walls or windows, by night or day, to hear news, and to carry them to others, to cause strife and contention among neighbours. These are evil members in the commonwealth, and therefore by stat. Westminster 1. c. 33, are to be punished; and this misdeameanor is presentable and punishable in the court leet.

EUGENIA, the yamboo, a genus of the monogynia order, in the icosandria class of plants, and in the natural method ranking under the 19th order, hesperideæ. The calyx is quadripartite, superior; the petals four; the fruit a monospermous quadrangular plum. There are 11 species, natives of the hot parts of Asia and America. They rise from 20 to 30 feet high; and bear plum-shaped fruit, inclosing one nut. They are too tender to live in this country, unless they are constantly kept in a stove.

EVICTION, in law, signifies a recovery of lands or tenements by law.

When lands, &c. are evicted before rent reserved upon a lease becomes due, the lessee is not liable to pay any rent. Likewise, if on an exchange of lands, either of the parties is evicted of the land given in exchange, the party evicted may in that case re-enter his own lands. And a widow being evicted of her thirds, shall be endowed in the other lands of the heir.

EVIDENCE, is the testimony adduced before a court or magistrate of competent jurisdistion, by which such court or magistrate are enabled to ascertain any fact which may be litigated between the parties.

This may be of two kinds, viz. written or verbal: the former by deeds, bonds, or other written documents; the latter by witnesses examined viva voce.

Evidence may be further divided into absolute and presumptive; the former is direct, in positive or obsolute affirmance or denial of any particular fact; the latter collateral, and from the conduct of the parties, affords an inference that such a particular fact did or did not occur.

The party making an affirmative allegation which is denied by his adversary, is in general required to prove it: unless indeed a man is charged with not doing an act, which by law he is required to do; for here a different rule must necessarily prevail. And the rule is, that the evidence must be applied to the particular fact in dispute; and therefore no evidence not relating to the issue, or in some manner connected with it, can be received; nor can the character of either party, unless put in issue by the very proceeding itself, be called in question; for the cause is to be decided on its own circumstances, and not to be prejudiced by any matter foreign to it.

It is an established principle, that the best evidence the nature of the case will admit shall be produced; for if it appears, that better evidence might have been brought forward, the very circumstance of its being withheld, furnishes a suspicion that it would have prejudiced the party in whose power it is, had he produced it. Thus if a written contract is in the custody of the party, no verbal testimony can be received of its contents.

The law never gives credit to the bare assertion of any one, however high his rank or pure his morals; but requires (except in particular cases with respect to quakers) the sanction of an oath, and the personal attendance of the party in court that he may be examined and cross-

examined by the different parties; and therefore in cases depending on parole or verbal evidence, the testimony of persons who are themselves conversant with the facts they relate, must be produced; the law paying no regard, except under special circumstances, to any hearsay evidence. Thus in some cases, the memorandum in writing made at the time, by a person since deceased, in the ordinary way of his business, and which is corroborated by other circumstances, will be admitted as evidence of the fact.

What a party himself has been heard to say, does not fall within the objection. As to hearsay evidence, any thing therefore, which the party admits, or which another asserts in his presence and he does not contradict, is received as evidence against him; but what is said by his wife, or any other member of his family, in his absence, will be rejected.

But a distinction must be made between admission, and an offer of compromise, after a dispute has arisen. An offer to pay a sum of money in order to get rid of an action, is not received in evidence of a debt, because such offers are made to stop litigation, without regard to the question whether any thing or what is due.

Admissions of particular articles before arbitration are also good evidence, for they are not made with a view to compromise, but the parties are contesting their rights as much as they could do on a trial.

In cases where positive and direct evidence is not to be looked for, the proof of circumstance and fact consistent with the claim of one party, and inconsistent with that of the other, is deemed sufficient to enable the jury, under the direction of the court of justice, to presume the particular fact, which is the subject of controversy; for the mind comparing the circumstances of the particular case, judges therefrom as to the probability of the story, and for want of better evidence, draws a conclusion from that before it.

Written evidence has been divided into two classes: the one that which is public, the other private; and this first has been subdivided into matters of record, and others of an inferior nature.

The memorials of the legislature, such as acts of parliament, and other proceedings of the two houses, where acting in a legislative character, and judgment of the king's superior courts of justice, are denominated records; and are so respected by the law, that no evidence whatever can be received in contradiction of them; but these are not permitted to be removed from place to place, to serve a private purpose; and are therefore proved by copies of them, which in the absence of the original, are the next best evidence.

Of persons incompetent to give evidence.—All persons who are examined as witnesses, must be fully possessed of their understanding; that is, such an understanding as enables them to retain in memory the events of which they have been witnesses, and give them a knowledge of right and wrong.

A conviction of treason or felony, and every species thereof, such as perjury, conspiracy, barratry, &c. prevents a man when convicted of them, from being examined in a court of justice. When a man is convicted of any of the offences before-mentioned, and judgment is entered up, he is for ever after incompetent to give evidence, unless the stigma is removed, which in case of a conviction of perjury, on the stat. of 5 Eliz. c. 9. can never be by any means short of a reversal of the judgment; for the statute has in this case, made his incompetency part of his punishment: but if a man is convicted of perjury, or any other offence, at the common law, and the king pardons him in particular, or grants a general pardon to all such convicts, this restores him to his credit, and the judgment no longer forms an objection to his testimony; but an actual pardon must be shown under the great seal, the warrant for it under the king's sign manual not being sufficient. To found this objection to the testimony of a witness, the party who intends to make it, should be prepared with a copy of the judgment regularly entered upon the verdict of conviction; for until such judgment is entered, the witness is not deprived of his legal privileges.

Persons may also be incompetent witnesses, by reason of their interest in the cause. The rule which has the most extensive operation in the exclusion of witnesses, and which has been found most difficult in its application, is that which prevents persons interested in the event of a suit, unless in a few excepted cases of evident necessity, from being witnesses in it. Of late years the courts have endeavoured, as far as possible consistent with authorities, to let the objection go to the credit rather than the competency of a witness; and the general rule now established is, that no objection can be made to a witness on this ground, unless he is distinctly interested, that is, unless he may be immediately benefited or injured by the event of the suit, or unless the verdict to be obtained by his evidence, or given against it, will be evidence for or against him in another action, in which he may afterwards be a party; any smaller degree of interest, as the possibility that he may be liable to an action in a certain event, or that, standing in a similar situation with the party by whom he is called, the decision in that cause, may by possibility influence the minds of a jury in his own, or the like; though it furnishes a strong argument against his credibility, does not destroy his competency.

On the question, how far persons who have been defrauded of securities, or injured by a perjury or other crime, can be witnesses in prosecuting for those offences, the event of which might possibly exonerate them from an obligation they are charged to have entered into, or restore to them money which they have been obliged to pay; the general principle now established is this: the question in a criminal prosecution or personal act, being the same with that in a civil cause in which the witnesses are interested, goes generally to the credit, unless the judgment in the prosecution where they are witnesses, can be given in evidence in this cause, wherein they are interested. But though this is the general rule, an exception to it seems to be established in the case of forgery; for many cases have been decided, that a person whose hand-writing has been forged to an instrument, whereby if good he would be charged with a sum of money, or one who has paid money in consequence of such forgery, cannot be a witness on the indictment. In cases where the party injured cannot by possibility derive any benefit from the verdict in the prosecution, as in indictments for assault, and the like personal injury, his com-

petence has never been doubted. It is a general rule that a party cannot be examined as a witness, for he is in the highest degree interested in the event of it; but where a man is not in point of fact interested, but only a nominal party, as where members of a charitable institution are defendants in their corporate character, there is no objection to an individual member being examined as a witness for the corporation; for in this case he is giving evidence for the public body only, and not for himself as an individual. Peake's N. P. Cas. 153. Bul. N. P. 293.

But instances sometimes occur, in which persons substantially interested, and even parties in a cause, are permitted to be examined from the necessity of the case, and absolute impossibility of procuring other evidence.

In an action on the statute of Winton, the party robbed is a witness: and on the same principle of necessity it has been holden, that persons who become interested in the common course of business, and who alone can have knowledge of the fact, may be called as witnesses to prove it: as in the case of a servant who has been paid money, or a porter who in the way of his business delivers out or receives parcels, though the evidence whereby he charges another with the money or goods, exonerates himself from his liability to account to his master for them; for if this interest was to conclude testimony, there never would be evidence of any such facts. Bul. N. P. 289.

As no one can be witness for himself, it follows of course husband and wife, whose interest the law has united, are incompetent to give evidence on behalf of each other, or of any person whose interest is the same; and the law, considering the policy of marriage, also prevents them giving evidence against each other: for it would be hard that a wife, who could not be a witness for her husband, should be a witness against him; such a rule would occasion implacable divisions and quarrels between them. In like manner, as the law respects the private peace of men, it considers the confidential communications made for the purpose of defence in a court of justice. By permitting a party to intrust his cause in the hands of a third person, it establishes a confidence and trust between the client and person so employed.

Barristers and attorneys, to whom facts are related professionally during a cause, or in contemplation of it, are neither obliged nor permitted to disclose the facts so divulged during the pendency of that cause, nor at any future time; and if a foreigner, in communication with his attorney, has recourse to an interpreter, he is equally bound to secrecy.

Where a man has, by putting his name to an instrument, given a sanction to it, he has been held by some judges to be precluded or stopped from giving any evidence in a court of justice which may invalidate it; as in the case of a party to a bill of exchange or promissory note, who has been said not to be an admissible witness to destroy it, on the grounds that it would enable two persons to combine together, and by holding out a false credit to the world, deceive and impose on mankind. On this principle it was held that an indorser could not be a witness to prove notes usurious, in an action or a bond founded on such notes, though the notes themselves had been delivered up, on the execution of the bond. At one time this seems to have been understood as a general principle applicable to all instruments; but in a case where an underwriter of a policy of insurance, was called to prove the instrument void as against another underwriter, and objected to on this ground, the court declared, that it extended only to negotiable instruments, and he was admitted to give evidence destructive of the policy.

When a witness is not liable to any legal objection, he is first examined by the counsel for the party on whose behalf he comes to give evidence, as to his knowledge of the fact he is to prove. This examination, in cases of any intricacy, is a duty of no small importance in the counsel; for as on the one hand, the law will not allow him to put what are called leading questions, viz. to form them in such a way as would instruct the witness in the answers he is to give; so on the other, he should be careful that he makes himself sufficiently understood by the witness, who may otherwise omit some material circumstance of the case.

The party examined must depose those facts only of which he has an immediate knowledge and recollection; he may refresh his memory with a copy taken by himself from a day-book; and if he can then speak positively as to his recollection, it is sufficient; but if he has no recollection further than finding the entry in his book, the book itself must be produced. Where the defendant had signed acknowledgments of having received money, in a day-book of the plaintiff, and the plaintiff's clerk afterwards read over the items to him, and he acknowledged them all right, it was held. that the witness might refresh his memory by referring to the books, although there was no stop to the items on which the recept was written, for this was only proving a verbal acknowledgment, and not a written receipt.

Lord Ellenborough, upon the authority of lord chief justice Tully, has recently laid down a very important doctrine, viz. that no witness shall be bound to answer any question which tends to degrade himself, or to show him to be infamous.

EULOGY, in church history, a name by which the Greeks call the panis benedictus, or bread over which a blessing is pronounced, and which is distributed to those who are unqualified to communicate. The name eulogiæ was anciently given to the consecrated pieces of bread, which the bishops and priests sent to each other, for the keeping up a friendly correspondence: those presents likewise which were made out of respect or obligation, were called eulogiæ. St. Paulinus, bishop of Nola, about the end of the sixth century, having sent five eulogiæ, at one time, to Romanian, says, "I send you five pieces of bread, the ammunition of the warfare of Jesus Christ, under whose standard we fight."

Eulogy means likewise an encomium on any person, on account of some virtue or good quality. See Elogy.

EUMENIDES, Furies, in antiquity.

EUNOMIANS, in church history, christians in the fourth century. They were a branch of Arians, and took their name from Eunomius, bishop of Cyzicus, who was instructed by Ætius in the points which were then controverted in the church, after having at first followed

the profession of arms. Eunomius so well answered the designs of his master, and declaimed so vehemently against the divinity of the Word, that the people had recourse to the authority of the prince, and had him banished; but the Arians obtained his recal, and elected him bishop of Cyzicus. The manners and doctrines of the Eunomians were the same with those of the Arians.

EVOCATION, in Roman antiquity, a solemn invitation preferred by way of prayer, to the gods and goddesses of a besieged town, to forsake it and come over to the Romans, who always took it for granted that their prayers were heard, provided they could make themselves masters of the place.

EVOLUTE, in the higher geometry, a curve which, by being gradually opened, describes another curve. Such is the curve B C F (plate LIV. Miscel. fig. 85); for if a thread F C M be wrapped about, or applied to, the said curve, and then unwound again, the point M thereof will describe another curve A M M, called by Mr. Huygens, a curve described from evolution. The part of the thread, M C, is called the radius of the evolute, or of the osculatory circle described on the centre C with the radius M C.

Hence, 1. when the point B falls in A, the radius of the evolute M C is equal to the arch B C, but if not, to A B and the arch B C. 2. The radius of the evolute C M is perpendicular to the curve A M. 3. Because the radius M C of the evolute continually touches it, it is evident from its generation, that it may be described through innumerable points, if the tangents in the parts of the evolute are produced until they become equal to their corresponding arches. 4. The evolute of the common parabola is a parabola of the second kind, whose parameter is $\frac{27}{16}$ of the common one. 5. The evolute of a cycloid is another cycloid equal and similar to it. 6. All the arches of evolute curves are rectifiable, if the radii of the evolute can be expressed geometrically. Those who desire a more particular account of these curves, may refer to sir Isaac Newton's and MacLaurin's Fluxions, also Rowe's, Simpson's, and Vince's Fluxions.

EVOLUTION. See ALGEBRA.

EVOLUTION, in the art of war, the motion made by a body of troops, when they are obliged to change their form and disposition, in order to preseve a post, or occupy another, to attack an enemy with more advantage, or to be in a condition of defending themselves the better. See TACTICS.

EVOLVULUS, a genus of the tetragynia order, in the pentandria class of plants; and in the natural method ranking under the 29th order, campanaceæ. The calyx is pentaphyllous; the corrolla quinquefid and verticillated; the capsule trilocular; the seeds solitary. There are seven species, herbaceous plants, chiefly annuals of the East and West Indies.

EUNONYMUS, the spindle-tree; a genus of the monogynia order, in the pentandria class of plants, and in the natural method ranking under the 43d order, dumosæ. The corolla is pentapetalous; the capsule pentagonal, quinquelocular, quinquevalved, and coloured; the seeds hooded. There are eight species. Of these the most remarkable are; 1. the Europæus, has an upright woody stem ten or fifteen feet high, with oblong opposite leaves: from the sides of the branches proceed small bunches of greenish quadrifid flowers, succeeded by pentagonous capsules, disclosing their red seeds in a beautiful manner in autumn. 2. The Americanus, or evergreen spindle tree, has a shrubby stem, dividing into many opposite branches, rising six or eight feet high, with spear-shaped ever-green leaves growing opposite, and from the sides and ends of the branches. The flowers are quinquefid and whitish, and come out in small bunches, succeeded by roundish, rough, and protuberant capsules, which rarely perfect their seeds in this country. Both these species are hardy, and will succeed in any soil or situation. The berries of the first sort vomit and purge very violently, and are fatal to sheep. If powdered and sprinkled in the hair, they destroy lice. If the wood is cut when the plant is in blossom, it is tough and not easily broken; and in that state it is used by watchmakers for cleaning watches, and for making skewers and tooth-pickers. Cows, goats, and sheep, eat this plant; horses refuse it.

EUPAREA, a genus of the class and order pentandria monogynia. The calyx is five-leaved: corolla, five or twelve petalled: berry superior, one-celled: seeds many.

There is one species, an herbaceous plant of New Holland.

EUPATORIUM, hemp-agrimony; a genus of the polygamia æqualis order, in the syngenesia class of plants; and in the natural method ranking under the 49th order, compositæ. The receptacle is naked; the pappus feathery; the calyx imbricated and oblong; the style semibifid and long. There are 49 species, many of them herbaceous flowery perennials, producing annual stalks from two to three or five feet high, terminated by clusters of compound flowers of a red, purple, or white colour. They are easily propagated by seeds, or parting the roots in autumn or spring. One species, viz. the cannabinum, or water hemp-agrimony, is a native of Britain. It is found wild by the sides of rivers and ditches, and has pale red blossoms. It has an acrid smell, and a very bitter taste, with a considerable share of pungency. The leaves are much recommended for strengthening the tone of the viscera, and as an aperient; and said to have excellent effects in the dropsy, jaundice, and scorbutic disorders. Boerhaave informs us, that this is the common medicine of the turf-diggers in Holland, against scurvies, foul ulcers, and swellings in the feet, to which they are subject. The root of this plant is said to operate as a strong cathartic: but it is hardly used in Britain, and has no place in our pharmacopœias.

EUPHEMISM, in rhetoric, a figure which expresses things in themselves disagreeable and shocking, in terms implying the contrary quality: thus, the Pontus, or Black Sea, having the epithet ἀξενος, *i. e.* inhospitable, given it, from the savage cruelty of those who inhabited the neighbouring countries, this name, by euphemism, was changed into that of Euxinus.

Thus Ovid, Trist. lib. iii. el. 13.

> Dum me terrarum pars pene novissima Ponti,
> Euxinus falso nomine dictus, habet.

And again, in Trist. lib. v. el. 10.

> Quem tenet Euxini mendax cognomine litus.

In which significations, nobody will deny its being a species of irony: but every euphemism is not irony, for we sometimes use improper and soft terms in the same sense with the proper and harsh.

EUPHONY, in grammar, an easiness, smoothness, and elegance in pronunciation. It is properly a figure, whereby we suppress a letter that is too harsh, and convert it into a smoother, contrary to the ordinary rules; of this there are abundance of examples in all languages.

EUPHORBIA, spurge, a genus of the trigynia order, in the dodecandria class of plants; and in the natural method ranking under the 38th order, tricoccæ. The corolla is tetrapetalous or pentapetalous, placed on the calyx; the calyx is monophyllous and ventricose; the capsule tricoccous. There are 98 species, six of which are natives of Great Britain. They are mostly shrubby and herbaceous succulents, frequently armed with thorns, having stalks from ten or twelve inches to as many feet in height, with quadripetalous flowers of a whitish or yellow colour. They are easily propagated by cuttings; but the foreign kinds must be always kept in pots in a stove. If kept dry, they may be preserved for several months out of the ground, and then planted, when they will as readily take root as though they had been fresh. The juice of all the species is so acrid, that it corrodes and ulcerates the body wherever it is applied; so that physicians have seldom ventured to prescribe it internally. Warts, or corns, anointed with the juice, presently disappear. A drop of it put into the hollow of an aching tooth, gives relief, like other corrosives, by destroying the nerve. Some people rub it behind the ears, that it may blister. One of the foreign species, named esula, is such a violent corrosive, that if applied to any part of the body, it produces a violent inflammation, which is soon succeeded by a swelling that degenerates into a gangrene, and proves mortal. There is a species at the Cape, which supplies the Hottentots with an ingredient for poisoning their arrows. Their method of making this pernicious mixture, is by first taking the juice extracted from the euphorbia, and a kind of caterpillar peculiar to another plant which has much the appearance of a species of rhus. They mix the animal and vegetable matter; and after drying it, they point their arrows with this composition, which is supposed to be the most effectual poison of the whole country. The euphorbia itself is also used for this purpose, by throwing the branches into fountains of water frequented by wild beasts, which after drinking the water thus poisoned, seldom get one thousand yards from the brink of the fountain before they fall down and expire. This plant grows from about fifteen to twenty feet in height, sending out many branches full of strong spines. The natives cut off as many of the branches as they think necessary for the destruction of the animals they intend to poison. They generally conduct the water a few yards from the spring into a pit made for the purpose; after which they put in the euphorbia, and cover the spring, so that the creatures have no choice. No animal escapes which drinks of such water, though the flesh is not injured by the poison. The euphorbias may be easily distinguished from the cactuses and other plants, which they resemble, by pricking them with a pin, when a milky juice will always exude from the puncture. See Plate LV. Nat. Hist. fig. 189.

EUPHORBIUM, in pharmacy, a gum resin brought us always in loose, smooth, and glossy gold-coloured drops of granules. See Pharmacy.

EUPHRASIA, eyebright (from a vulgar notion that it was good in disorders of the eyes); a genus of the angiospermia order, in the didynamia class of plants; and in the natural method ranking under the 40th order, personatæ. The calyx is quadrifid and cylindrical; the capsule bilocular, ovato-oblong; the shorter two antheræ, with the base of the one lobe, terminated by a small spine. There are nine species; two of which annuals, viz. the officinalis and odontites, are natives of Britain. The first of these, which has blue flowers, is a weak astringent, and was formerly much celebrated in disorders of the eyes; but the present practice has not only disregarded its internal, but also its external, use. This plant will not grow but when surrounded by others taller than itself. Cows, horses, goats, and sheep, eat it; swine refuse it.

EURYA, a genus of the class and order dodecandria monogynia. The calyx is five-leaved, calycled; corolla, five-petalled; stamina, three; capsule, five-celled. There is one species, a shrubby plant of Japan.

EURYANDRA, a genus of the polyandria trigynia class and order. The calyx is five-leaved: corolla, three-petalled; filaments much dilated at top, with two disjointed antheræ; follicles, three. There is one species, a climbing plant of New Caledonia.

EURYTHMY, in architecture, painting, and sculpture, is a certain majesty, elegance and easiness, appearing in the composition of divers members, or parts of a body, painting, or sculpture, and resulting from the fine proportion of it. Vitruvius ranks the eurythmia among the essential parts of architecture; he describes it as consisting in the beauty of the construction, or assemblages of the several parts of the work, which renders its aspect, or its whole appearance, grateful; *e. g.* when the height corresponds to the breadth, and the breadth to the length.

EUSEBIANS, a name given to a sect of Arians. on account of the favour and countenance which Eusebius, bishop of Cæsarea, showed and procured for them at their first rise.

EUSTATHIANS, the same with the catholics of Antioch, in the fourth century; so called from their refusing to acknowledge any other bishop beside St. Eustathius, who was deposed by the Arians.

EUSTYLE, in architecture, a sort of building in which the pillars are placed at the most convenient distance from one another, the intercolumniations being just two diameters and a quarter of the column, except those in the middle of the face, before, and behind, which are three diameters distant.

EUTYCHIANS, in church history, christians in the fifth century, who embraced the errors of the monk Eutyches, maintaining that there was only one nature in Jesus Christ. The divine nature, according to them, had so entirely swallowed up the human, that the latter could not be distinguished; insomuch, that Jesus Christ was merely God, and had nothing of humanity but the appearance.

EWRY, in the British customs, an officer in the king's household, who has the care of the table-linen, of laying the cloth, and serving up water, in silver ewers, after dinner.

EXACTION, in law, a wrong done by an officer, or a person in pretended authority, in taking a reward or fee that is not allowed by law. A person guilty of exaction may be fined and imprisoned. It is often confounded with extortion.

EXACUM, a genus of the monogynia order, in the tetrandria class of plants, and in the natural method ranking under the 20th order, rotaceæ. The calyx is tetraphyllous; the corolla quadrifid, with the tube globular; the capsule two-furrowed, bilocular, polyspermous, and opening at the top. There are 10 species, allied to the gentians, chiefly annuals, of the East Indies and Cape.

EXÆRESIS, in surgery, the operation of extracting or taking away something that is hurtful to the human body.

EXAGGERATION, in rhetoric, a kind of hyperbole, wherein things are augmented or amplified, by saying more than the truth, either as to good or bad. There are two kinds of exaggeration; the one of things, the other of words. The first is produced, 1. By a multitude of definitions. 2. By a multitude of adjuncts. 3. By a detail of causes and effects. 4. By an enumeration of consequences. 5. By comparisons. And 6. By the contrast of epithets and rational inference.

Exaggeration by words is effected, 1. By using metaphors. 2. By hyperboles. 3. By synonymous terms. 4. By a collection of splendid and magnificent expressions. 5. By pariphrasis. 6. By repetition. And, lastly, by confirmation with an oath: as for example, "Parietes, medius fidius, gratias tibi agere gestiunt."

Exaggeration, in painting, a method by which the artist, in representing things, charges them too much, or makes them too strong, either in respect of the design or the colouring. It differs from caricaturing, as the latter perverts or gives a turn to the features of the face, &c. which they had not; whereas exaggeration only heightens or improves what they had.

EXAMINATION. Justices before whom any person shall be brought for manslaughter or for felony, or for suspicion thereof, before they commit such prisoner, shall take his examination, and information of those who bring him, of the fact and circumstances; and as much thereof as shall be material to prove the felony, shall be put in writing within two days after the examination; and the same shall certify in such manner as they should do if such prisoner had been bailed, upon such pain as in the act 1 and 2 P. and M. c. 13. is limited.

EXAMINERS, in chancery, two officers of that court, who examine, upon oath, witnesses produced in causes depending there, by either the complainant or defendant, where the witnesses live in London or near it. Sometimes parties themselves, by particular order, are examined. In the country, above twenty miles from London, on the parties joining in commission, witnesses are examined by commissioners, being usually counsellors or attorneys not concerned in the cause.

EXANTHEMA, among physicians, denotes any kind of efflorescence or eruption, as the measles, purple spots in the plague or malignant fevers, &c.

EXARCH, in antiquity, an officer sent by the emperors of the East into Italy, in quality of vicar, or rather præfect, to defend that part of Italy which was under their obedience, and particularly the city of Ravenna, against the Lombards. The exarch resided at Ravenna, which place, with Rome, was all that was left to the emperors of their Italian dominions. The first exarch was under Justin the Younger, in the year 567, after Belisarius and Narses had driven the barbarians out of Italy. The last was Eutychius, defeated by Adolphus, king of the Lombards, in 752. But Pepin, king of France, deprived him of the exarchate, and made a gift of it to the pope, ordering his chaplain to lay the keys of all the towns on the altar of St. Peter and Paul at Rome.

Exarch also denotes an officer still subsisting in the Greek church, being a kind of visitor, or one deputed by the patriarch into provinces, to see whether the bishops do their duty, and whether the rest of the clergy observe the canons of the church.

There is another officer also of this name under the patriarchs of the Greek church, who has the care and inspection of the patriarchal monasteries, or such as depend immediately on the patriarch.

EXAUCTORATION, *exauctoratio*, in Roman antiquity, corresponded, in some measure, to our keeping soldiers or sailors in half-pay; but differed in this, that the exauctorati milites were deprived of their pay and arms, without being absolutely discharged. Sometimes it signifies a full but ignominious discharge.

EXCALCEATION, among the Hebrews, was a particular law, whereby a widow, whom her husband's brother refused to marry, had a right to summon him to a court of justice, and, upon his refusal, might excalceate him, that is, pull off one of his shoes, and spit in his face; both of them actions of great ignominy.

EXCELLENCY, a title anciently given to kings and emperors, but now to ambassadors and other persons, who are not qualified for that of "highness," and yet are to be elevated above the other inferior dignities.

In England and France the title is now peculiar to ambassadors, but very common in Germany and Italy. Those it was first appropriated to were the princes of the blood of the several royal houses; but they quitted it for that of highness, upon several great lords assuming excellency. The ambassadors have only borne it since the year 1593, when the pope complimented the duke de Nevers, ambassador from Henry IV. of France, with the title of excellency; and though it was on account of his birth, and not of his character, yet the ambassadors of all nations have ever since claimed the same appellation.

The ambassadors of Venice have only had the title of excellency since the year 1636, when the emperor and king of Spain consented to allow it to them. The court of Rome never allows that title to any ambassador who is a churchman, as judging it a secular title.

The ambassadors of France at Rome anciently gave the title of excellency to all the relations of the pope then reigning, and to several other noblemen; but now they are more reserved in that respect, though they still treat all the Roman princes with excellency: on the other hand, the court of Rome bestowed the same title on the chancellor, ministers, and secretaries of state,

and presidents of the sovereign courts of France, the presidents of the councils in Spain, and the chancellor of Poland, if they were not ecclesiastics.

EXCENTRIC, in geometry, a term applied to circles and spheres which have not the same centre, and consequently are not parallel; in opposition to concentric, where they are parallel, having one common centre.

EXCENTRIC, or *excentric circle*, in astronomy, is the circle described from the centre of the orbit of a planet, with half the greatest axis as a radius; or it is the circle that circumscribes the elliptic orbit of the planet, as the circle AQB. See Plate LIV. Miscel. fig. 86.

EXCENTRIC *anomaly*, or *anomaly of the centre*, is an arc AQ of the excentric circle, intercepted between the aphelion A, and the right line QH, drawn through the centre P of the planet perpendicular to the line of the apses AB.

EXCENTRIC *place of a planet*, is the point of the orbit where the circle of inclination coming from the place of a planet in its orbit, falls thereon with right angles.

EXCENTRICITY, in astronomy, is the distance CS between the sun S and the centre C of a planet's orbit; or the distance of the centre from the focus of the elliptic orbit, called also the simple or single excentricity. Fig. 86.

When the greatest equation of the centre is given, the excentricity of the earth's orbit may be found by the following proportion, viz.

As the diameter of a circle in degrees,
Is to the diameter in equal parts;
So the greatest equat. of the centre in degrees,
To the excentricity in equal parts. Thus,

Greatest equat. of the cent. $1^\circ\ 55'\ 33'' = 1^\circ.9258333$ &c.

The diameter of a circle being 1, its circumference is 3.1415926.

Then $3.1415926 : 1 :: 360^\circ : 114^\circ.5915609$ diameter in degrees.

And $114.5915609 : 1 :: 1.9258333 : 0.016806$, the excentricity.

Hence, adding this to 1, and subtracting it from 1,
Give $1{\cdot}016806 =$ AS the aphelion distance,
And $0{\cdot}983194 =$ BS the perihelion distance.

See Robertson's Elements of Navigation, book 5, pa. 286.

Otherwise, thus: Since it is found that the sun's greatest apparent semidiameter, is to his least, as $32'\ 43''$ to $31'\ 38''$, or as $1963''$ to $1898''$; the sun's greatest distance from the earth will be to his least, or AS to SB, 1963 to 1898; of which,

The half-dif. is $32\frac{1}{2} =$ CS,
And half-sum $1930\frac{1}{2} =$ CB; wherefore,
as $1930\frac{1}{2} : 32\frac{1}{2} :: 1 : .016835'' =$ CS the excentricity, to the mean distance or semi-axis 1; which is nearly the same as before.

The excentricities of the orbits of the several planets, in parts of their own mean distances 1000, and also in English miles, are as below, viz. the excentricity of the orbit of

		Parts.	Miles.
Mercury			7,730,000
Venus	-	7	482,000
Earth	-	17	1,618,000
Mars	-	93	13,486,000
Jupiter	-	48	23,760,000
Saturn	-	55	49,940,000
Herschel	-	$47\frac{1}{2}$	86,000,000
Piazzi	-	0,0364	

Double EXCENTRICITY, is the distance between the two foci of the elliptic orbit, and is equal to double the single excentricity above given.

To find the excentricity of the earth's orbit, and the place of the apsides.—Take an observation of Mars when he is in opposition with the Sun, and then if Mars be in M. (Plate LIV. Miscel. fig. 87.) the Sun in S, and the Earth in T, they will be all in the same right line M T S. When Mars, after 687 days, returns again to the same point M, and the Earth, not reaching the same till after $730\frac{1}{2}$ days, in which time she completes two revolutions in her orbit, is found in the point A, observe the place of the Sun seen from the Earth by the right line A S, and the place of Mars seen by the right line A M. We have, therefore, by means of the Sun's place in E, at the time of the second observation, and his place in F, at the time of the first observation, the angle E S F given, to which the angle M S A is equal. And by knowing the place of the Sun and Mars in the 2d observation, we have the distance of Mars from the Sun, or the angle M A S. In the same manner may be found the angle M S B, and B S, the distance of the Earth from the Sun in decimal parts of M S, when Mars returns a second time to M, and likewise the angle M S C, and the right line S C, when Mars returns a third time to M. Wherefore since the focus of the earth's orbit is in S, and A, B, and C are points in that orbit, the line of the apsides will be determined, the orbit will be described, and consequently the excentricity will be known. The excentricity of all the primary planets, and the position of the line of apsides, may be found in the same manner, if three heliocentric places of the planet, together with its true distance from the Sun, are known. But it must be observed, that we suppose that the planet, in the same point of its orbit, has the same distance from the Sun, which we may easily suppose on account of the slowness of the motion of the aphelia.

The excentricity of the moon's orbit is about 3, 3 of the semi-diameter of the Earth, and now and then it grows greater and now and then it diminishes. It is greatest when the line of the apsides is coincident with the syzygia, or is in the line which joins the centres of the Sun and Earth. And the excentricity is least when the line of the apsides cuts the other at right angles. The difference between the greatest and least excentricity is so considerable, that it exceeds the half of the least excentricity.

EXCEPTION in law, is a stop or stay to any action. In law proceedings, it is a denial of a matter alleged in bar to an action; and in chancery, it is what is alleged against the sufficiency of an answer.

EXCEPTION TO EVIDENCE. At common law, a writ of error lay for an error in law, apparent on the record, or for an error in fact, where either party died before judgment; yet it lay not for an error in law not appearing on the record. 2 Inst. 426.

By the stat. of Westminster 2, when one impleaded before any of the justices, alleges an exception, praying they will allow it; and if they will not, if he that alleges the exception writes the same, and requires the justices will put thereto their seals; the justices shall so do: and if upon complaint made of the justices, the king causes the record to come before him, and the exception is not found in the roll, and the plaintiff shows the written exception, with the seal of the justices thereto put, the justice shall be commanded to appear at a certain day, either to confess or deny his seal, and if he cannot deny his seal, they shall proceed to judgment according to the exception, as it ought to be allowed or disallowed.

The statute extends to the plaintiff as well as the defendant, also to him who comes in loco tenements, as one that prays to be received, or the vouchee; and in all actions, whether real, personal, or mixt. 2 Inst. 427.

Exception *in deeds and writings*, the exception in a clause whereby the donor, feoffer, grantor, or other person contracting, excepts or takes a particular thing out of a general thing granted or conveyed. The thing excepted is exempted, and does not pass by the grant, neither is it parcel of the thing granted; as if a manor be granted, excepting one acre, hereby in judgment of law, that acre is severed from the manor. 1 Wood's Convey. 241. Exception must be of such a thing as he who makes it may have, and does belong to him. It must not be the whole thing granted, but part thereof only. The thing excepted, must be part of the thing granted before, and not of some other thing. The thing excepted, must be such a thing as may be severed from the thing granted, and not inseparable incidents. It must be of a particular thing out of a general, or of an entire thing, and not of a particular out of a particular, or the whole thing itself granted. An exception must be conformable to the grant, and not repugnant thereto; and the thing excepted must be certainly described and set down.

EXCESS, in arithmetic and geometry, is the difference between any two unequal numbers or quantities, or that which is left after the lesser is taken from or out of the greater.

EXCHANGE, in law, is a mutual grant of equal interests, the one in consideration of the other. 2 Black. 323.

An exchange may be made of things that lie either in grant or in livery. But no livery of seisin, even in exchanges of freehold, is necessary to perfect the conveyance: for each party stands in the place of the other, and occupies his right, and each of them has already had corporal possession of his own land. But entry must be made on both sides; for if either party die before the entry, exchange is void, for want of sufficient notoriety. Id.

In exchange, the estates of both parties should be equal; that is, if the one has a fee simple in the one land, the other should have like estate in the other land: and if the one has fee-tail in the one land, the other ought to have the like estate in the other land: and so of other estates. But it is not material in the exchange, that the lands be of equal value, but only that they be equal in kind and manner of the estate given and taken. 1 Inst. 51.

Exchanges, are carried on by merchants and bankers all over Europe, and are transacted on the Royal Exchange of London, the Royal Exchange of Dublin, the Exchange of Amsterdam, and those of the principal cities of the continent. The mode of exchanging between one kingdom or nation and another, is, the one gives the certain price, and the other the uncertain price of exchange to each other: *i. e.* England gives the certain price, viz. one pound sterling, to France, for an uncertain number of livres to be paid or received there, and gives the same to Hamburgh, Holland, and the Netherlands, for an uncertain number of schillings and pence Flemish, or of guilders and stivers; and she gives the uncertain price, viz. an uncertain number of pence and parts of pence, to other nations: as for example, she gives from 60*d.* to 70*d.* (more or less) to Lisdon or Oporto for one of their milreis (or 1000 reis); from 30*d.* to 40*d.* to Madrid, Cadiz, &c. for their piastre or dollar; from 35*d.* to 55*d.* to Genoa and Leghorn for a pezzo, or dollar of 5 livres banco at Genoa, and 6 livres at Leghorn; from 25*d.* to 45*d.* to Naples for a ducat of 10 carlins or 100 grains; from 36*d.* to 56*d.* to Venice for a ducato banco of 24 grossi; from 30*d.* to 40*d.* to Petersburgh for a rouble of 100 copecks; and to Dublin and all parts of Ireland 100*l.* sterling for an uncertain number of pounds, shillings, and pence Irish, to be paid or received there, viz. from 105*l.* up to 115*l.* Irish, as exchange may be.

The par of exchange (or par pro pari) is the intrinsic value of the different species of money on the continent, equalized to those of England, and vice versa; as for instance, the par of exchange between England and Ireland is $8\frac{1}{3}$ per cent. or, in other words, 108*l.* 6*s.* 8*d.* Irish, are equal to 100*l.* English; the English shilling being current in that country for 13*d.* consequently the pound sterling is 1*l.* 1*s.* 8*d.* therefore when the exchange from London on Dublin is 12*l.* per cent. there is a profit or saving of 3*l.* 13*s.* 4*d.* per cent. on every 100*l.* sterling remitted to Ireland.

The course of exchange is always fluctuating, sometimes under, and sometimes over the par of exchange, and is chiefly governed by the balance of trade being for or against the negotiating parties; so that when the exchange is above par, the balance of trade is certainly against them, and when it is under par, it is consequently in their favour. If London ships to Hamburgh merchandize to the amount of 500,000*l.* and at the same time Hamburgh ships to London goods or merchandize to only the amount of 300,000*l.* Hamburgh can only discharge to the amount of 300,000*l.* by bills of exchange, and for the remaining balance of 200,000*l.* she must procure bills of exchange at the lowest possible premium elsewhere, in order to liquidate the debt due to London, (as it is not to be supposed that Hamburgh, being indebted to London, can furnish bills on equally good terms with another city not indebted to London): thus Hamburgh by paying a premium (of suppose 1 per cent.) for bills of exchange, would have to pay 202,000*l.* in order to liquidate the aforesaid balance of 200,000*l.* thereby losing 2000*l.* on the transaction.

Thus it is that the balance of trade effects the fluctuation of exchanges. The principal exchanges of Europe are governed by those of London, Amsterdam, and Venice, and the exchanges from foreign countries are to be only

had by advices from the merchants and bankers residing abroad.

It frequently happens, that sums of money sent to the continent for subsidies and the like purposes, have their influence on the course of exchange, as it enables the merchants resident there to keep down the exchange, were they even obliged to remit over their balances in cash.

When England remits to Spain, Portugal, Italy, or any other kingdom or nation to which it gives the uncertain price, the lower the price of exchange is, the more it is to the advantage of England; as for instance, giving to Spain 35*d*. for their piastre or dollar, instead of giving 36*d*. to 38*d*. giving 60*d*. to Portugal for the milreis, instead of giving 66*d*. the same with Italy, &c. The contrary is to be observed in drawing.

When England remits to France, Holland, Hamburgh, Ireland, and all other places to which it gives the certain price, the higher the exchange is, the better: as for instance giving to France 1*l*. sterling for 26 livres, is better than 25 or 24 livres; giving to Holland 1*l*. sterling, for 36 schillings Flemish, is better than 35 or 34 schillings Flemish; or 112*l*. Irish for the 100*l*. sterling, than 108*l*. 6*s*. 8*d*. the par of exchange; the contrary to be observed in drawing.

It is to be remarked that the course of exchange governs the entire sum which is to be negotiated; and although it would appear at the place which gives the certain price, that the fluctuation falls altogether upon the other, yet it is not so, as it falls equally on both; for one may as well say that 100*l*. sterling is only equal to 106*l*. Irish, when the exchange is 6 per cent. (though the par is 108*l*. 6*s*. 8*d*.) as that 100*l*. sterling is equal in value to 112*l*. Irish, when the exchange is 12 per cent. and so of other exchanges. The certain price always falls or rises in its value, as the course is above or below par, and the uncertain price fluctuates in value the contrary way.

As banco money of Holland is always better than cash or current money, so there is usually a difference which is called the agio, and fluctuates from $1\frac{1}{8}$ to $5\frac{3}{8}$ per cent.

The exchanges on the continent are negotiated in the following manner, subject to the like fluctuations as before mentioned: viz.

From Amsterdam to London, from 30 to 40 schillings Flemish, per pound sterling.
to Paris, Bourdeaux, &c. from 50 to 60 groots Flemish, per ecu of 3 livres.
to Madrid, Cadiz, &c. from 90 to 100 ditto, per ducat of 375 marvedis plate.
to Lisbon, Porto, &c. from 40 to 50 ditto, per crusado, or crown of 400 reis.
to Genoa and Leghorn, from 80 to 90 ditto, per pezzo or dollar, of 5 livres banco at Genoa, or 6 livers at Leghorn.
to Hamburgh, from 30 to 40 stivers, per exchange ducat of 2 marks.
to Petersburgh, from 40 to 50 stivers current per rouble.

From Paris, Bourdeaux, &c. to London, from 20*d*. to 36*d*. per ecu, or crown of 3 livres.
to Amsterdam, from 50 to 60 groots Flemish, per ecu of ditto.
to Madrid, Cadiz, &c. from 13 to 17 livers, per doubloon, of 32 reals old plate.
to Lisbon, Porto, &c. from 4 to 500 reis per ecu.
to Genoa and Leghorn, from 90 to 100 sous, per dollar or pezzi of livres, 5.15 fuera banco at Genoa, or 6 livres at Leghorn.
to Hamburgh, from 25 to 28 schillings banco, per ecu of three livres.

From Naples to London, from 30*d*. to 50*d*. per ducato.

From Venice to London, from 40*d*. to 60*d*. per ducat of 24 grossi.

From Madrid, Cadiz, &c. to London, from 30*d*. to 40d. per peso or dollar of 8 reals old plate.
to Hamburgh, from 70 to 80 groots, per ducat of 375 marvedis.
to Amsterdam, from 90 to 100 groots Flemish, per ditto.
to Paris, Bourdeaux, &c. from 13 to 17 livres per doubloon of 32 reals old plate
to Lisbon, Porto, &c. from 2000 to 2200 reis, per doubloon old plate.
to Genoa, from 620 to 660 marvedis plate, per escudo d'ore marche.
to ditto, from 21 to 25 livres fuera banco, per pistole of 40 reals plata.
to Leghorn, from 120 to 130 pesos or Spanish dollars, for 100 pezzi or Leghorn dollars of 6 liras each.

From Lisbon and Porto to London, from 60*d*. 75*d*. per millrea.
to Amsterdam, from 40 to 50 groots Flemish per crusado of 400 reis.
to Paris, Bourdeaux, &c. from 450 to 500 reis per ecu of 3 livres.
to Madrid, &c. from 2000 to 2200 reis per doubloon, of 33 reals plata.
to Genoa and Leghorn, from 600 to 800 reis, per peso or dollar of livres 5.15 at Genoa, or 6 livres at Leghorn.
to Hamburgh, from 40 to 50 groots Flemish, per crusado of 400 reis.

From Genoa and Leghorn to London, from 40*d*. to 50*d*. per dollar or pezzo of 5 livres banco.
to Amsterdam from 80 to 90 groots Flemish, per ditto.
to Paris, Bourdeaux, &c. from 90 to 100 sols, per ditto.
to Madrid, from 620 to 660 marvedis plate, per escudo d'ore marche, (or 22 to 24 livres per pistole of 40 reals plata.)
to Cadiz from 120 to 130 pesos per 100 pezzi.
to Lisbon, Porto, &c. from 600 to 800 reis per dollar, of livres 5.15 fuero banco.

From Hamburgh to London, from 30 to 40 schillings Flemish per pound sterling.
to paris, Bourdeaux, &c. from 25 to 28 schillings bank, per ecu of 3 livres.
to Madrid, Cadiz, &c. from 60 to 80 groots, per ducat of 375 marvedis.
to Amsterdam, from 30 to 40 stivers, per 2 banco marks.
to Lisbon and Porto, from 40 to 50 groots Flemish, per crusado of 400 reis.
From Petersburgh to London, from 25*d.* to 40*d.* per rouble.
to Amsterdam, from 40 to 50 stivers per rouble.
to Hamburgh, from 25 to 35 schillings banco per rouble.

We shall now give some examples of the operations of exchange between London and those places with which she has a direct exchange.

Moneys of exchange and regulations with regard to London.

A pound = 20 shillings, or 240 pence.

A shilling = 12 pence, or 48 farthings.

Accounts are kept in pounds, shillings, and pence: some reckon farthings.

Value of usances for bills drawn from

France, Hamburgh, and Holland	1 month after date.
Portugal and Spain - -	2 months after date.
Italy - - - - -	3 months after date.

There are three days of grace, which begin the day after the bills are due, and on the third day they must be paid or protested. Bills due on Sunday must be paid or protested on Saturday: for those at sight, no days of grace are allowed.

LONDON.—*Course of Exchange.*

		Uncertain Prices.		Certain Prices.
Amsterdam	*giv.*	37 shillings Flemish	*for*	1 pound sterling.
Dublin	*giv.*	110½ pounds Irish	*for*	100 pounds British.
France	*giv.*	25 livres tournois	*for*	1 pound sterling.
Idem	*giv.*	25 francs	*for*	1 pound sterling.
Genoa	*rec.*	46 pence sterling	*for*	1 pezza fuori di banco.
Hamburgh	*giv.*	35 shillings Flemish	*for*	1 pound sterling.
Leghorn	*rec.*	50 pence sterling	*for*	1 pezza of 8 reals.
Naples	*rec.*	39 pence sterling	*for*	1 ducat di regno.
Portugal	*rec.*	63½ pence sterling	*for*	milreis.
Rotterdam	*giv.*	12 florins current	*for*	1 pound sterling.
Spain	*rec.*	36 pence sterling	*for*	1 dollar of exchange.
Venice	*giv.*	58 lire piccole	*for*	1 pound sterling.

N. B. As Bourdeaux and Bayonne exchange with London by francs, it is thought expedient to include the calculation of this exchange under the head of France.

London on Amsterdam.

Reduce 4086 florins 4 stivers 6 pennings banco into pounds, shillings, and pence sterling, at the exchange of 38 shillings 2 grotes Flemish banco per pound sterling.

Here 1 florin = 40 grotes
12 grotes = 1 shilling
38 shill. 2 grot. = 1 pound.

Rule.—Multiply 4086 4 6 by 40 grotes; divide the product by 38 2, price of exchange, and by 12 grotes.

```
 38  2          4086 4 6
 12               40
----           -------
458 div.       163440
   for 4 stivers     8
   for 6 penings     3/4
               -------
       458)163448 3/4(356 17 6 result by
                         common division.
```

N. B. When the price of exchange consists of shillings Flemish only, multiply the sum by 10 instead of 40, and multiply the price of exchange by 3 instead of 12.

London on Dublin.

Reduce 293 pounds 10 shillings 6 pence Irish into pounds, shillings, and pence British, at the exchange of 14 per cent.

114*l.* Irish = 100*l.* British.

Rule.—Multiply 293 10 6 by 100, and divide the product by 114, price of exchange.

```
           293 10 6
           100
          ------
          29300
for 10 shill.  50
for 6 pence     2 10
     114)29352 10(257 9 6 result by common division.
```

To prove this operation, that is, to calculate the exchange of Dublin on London, multiply 257 9 6 by 114, price of exchange, and divide the product by 100.

N. B. British money is 8⅓ per cent. better than the Irish; therefore

12 pounds British = 13 pounds Irish.

London on France.

Reduce 3222 livres 2 sols 9 deniers tournois into pounds, shillings, and pence sterling, at the exchange of 25 livres 14 sols tournois per pound sterling.

Here 25 liv. 14 sols = 1 pound.

Rule.—Divide 3222 2 9 by 25 14, price of exchange.

```
25 14          3222 2 9
20 fraction    20 fraction
-----          --------
514 div.   514)64442 15(125 7 6 result.
```

Reduce 2545 francs 41 cents into pounds, shillings, and pence sterling, at the exchange of 24 francs 80 cents per pound sterling.

Here 24 francs 80 cents = 1 pound.

Rule.—Divide 2545 41 by 24 80, price of exchange.

2480)254541(102 12 9 result.

London on Genoa.

Reduce 1277 pezze 13 soldi 4 denari fuori di banco into pounds, shillings, and pence sterling, at the exchange of 45 pence sterling per pezza of 115 soldi fuori di banco.

Here 1 pezza = 45 pence
240 pence = 1 pound.

Rule.—Multiply 1277 13 4 by 45, price of exchange, and divide the product by 240 pence.

```
            1277  13  4
              45
            ------------
            6385
           5108
for 10 soldi    -   -   22  10
for  3 do. 4 denari      7  10
            ------------
         12)57495
            ------------
         20) 4791   3
            ------------
             239  11  3 result.
```

London on Hamburgh.

Reduce 1416 marcs 1 shilling 6 fenings lubs banco into pounds, shillings, and pence sterling, at the exchange of 35 shillings 4 grotes Flemish banco per pound sterling.

Here 1 marc = 32 grotes
12 grotes = 1 shilling
35 shill. 4 grot. = 1 pound.

Rule.—Multiply 1416 1 6 by 32 grotes; divide the product by 35 4, price of exchange, and by 12 grotes.

```
 35  4            1416  1  6
 12                 32
 ----             --------
424 div.          2832
                 4248
for 1 shilling  -     2
for 6 fenings   -     1
                ---------
         424)45315(106  17  6 result.
```

N. B. When the price of exchange consists of shillings Flemish only, multiply the sum by 8 instead of 32, and multiply the price of exchange by 3 instead of 12.

London on Leghorn.

Reduce 664 pezze 7 soldi 6 denari of 8 reals, into pounds, shillings, and pence sterling, at the exchange of 48 pence sterling per pezza of 8 reals.

1 pezza = 48 pence
240 pence = 1 pound.

Rule.—Multiply 664 7 6 by 48, price of exchange, and divide the product by 240 pence.

```
            664  7  6
             48
            ----------
            5312
           2656
for 5 soldi           12
for 2 do. 6 den.       6
            ----------
         12)31890
            ----------
         20) 2657   6
            ----------
             132  17  6 result.
```

London on Naples.

Reduce 1014 ducats 16 grains di regno into pounds, shillings, and pence sterling, at the exchange of $37\frac{1}{2}$ pence sterling per ducat di regno.

1 ducat = $37\frac{1}{2}$ pence
240 pence = 1 pound.

Rule.—Multiply 1014 16 by $37\frac{1}{2}$ price of exchange, and divide the product by 240 pence.

```
               1014  16
                 37½
               ---------
               7098
              3042
for ½       -   507
for 16 grains  -  6
               ---------
            12)38031
               ---------
            20) 3169  3
               ---------
               158  9  3 result
```

London on Portugal.

Reduce 566880 reis into pounds, shillings, and pence sterling, at the exchange of $62\frac{1}{2}$ pence per mil reis.

1000 reis = $62\frac{1}{2}$ pence
240 pence = 1 pound.

Rule.—Multiply 566880 by $62\frac{1}{2}$, price of exchange; divide the product by 1000 reis, and the quotient by 240 pence.

```
               566880
                  62½
              ---------
              1133760
             3401280
for ½          283440
              ---------
       1,000)35430.000
              ---------
           12)35430
              ---------
           20) 2952  6
              ---------
              147  12  6 result.
```

N. B. To divide the product by 1000 separate the three right hand figures, and when they are or exceed 500, add one unit.

London on Rotterdam.

Reduce 2401 florins 17 stivers 8 penings current into pounds, shillings, and pence sterling, at the exchange of 12 florins 4 stivers current per pound sterling.

12 florins 4 stivers = 1 pound.

Rule.—Divide 2401 17 8 by 12 4 price of exchange.

```
 12  4                    2401  17  8
 20 fraction                20 fraction
 -----                    ------------
244 div.           244)48037½(196  17  6 result.
```

London on Spain.

Reduce 4643 dollars 6 reals 17 maravedis of plate into pounds, shillings, and pence sterling, at the exchange of $35\frac{1}{2}$ pence sterling per dollar of exchange.

1 dollar = $35\frac{1}{2}$ pence
240 pence = 1 pound.

Rule.—Multiply 2643 6 17 by $35\frac{1}{2}$, price of exchange, and divide the product by 240 pence.

```
            2643  6  17
              35½
            -----------
            13215
            7929
for ½   -   1321  4
```

for 4 reals	-	17 6
for 2 ditto	-	8 7
for 17 maravedis		2 1 25½
		12)93855 2 25½
		20) 7821 3
		391 1 3 result.

London on Venice.

Reduce 14783 lire 3 soldi 9 denari piccole into pounds, shillings, and pence sterling, at the exchange of 59 lire piccole effective per pound sterling.

59 lire = 1 pound.

Rule.—Divide 14783 3 9 by 59, price of exchange.

59)14783 3 9(250 11 3 result.

We shall now give some other examples of the operations of exchange. First, between Holland and some places with which she has a direct exchange.

Amsterdam and Holland.

Moneys of Exchange, and Regulations.

A rixdollar (rixdalder) = 2½ florins = 50 stivers = 8⅓ shillings Flemish or 100 grotes Flemish.

A florin or guilder (gulden) = 20 stivers = 3⅓ shillings Flemish or 40 grotes Flemish.

A stiver (stuyver) = 16 penings or 2 grotes Flemish.

A pound Flemish (pond Flaams) = 20 shillings Flemish = 240 grotes Flemish or 6 florins.

A shilling Flemish (schilling Flaams) = 12 grotes Flemish or 6 stivers.

A grote Flemish (groot Flaams) = ½ stiver or 8 penings.

2 rixdollars = 5 florins
3 rixdollars = 25 shillings Flemish
3 florins = 10 shillings Flemish.

Accounts are kept in florins, stivers, and penings.

Value of usances for bills drawn from
England and France, 1 month after date.
Italy. Portugal, and Spain, 2 months after date.
Dantzic and Konigsberg, 40 a 70 days after date.
Germany and Switzerland 14 days after sight.

There are 6 days of grace, Sundays and holidays included, for bills of exchange drawn in current money; but for those drawn in bank money, no days of grace are generally allowed, and bills are protested on the second or third day after they become due.

AMSTERDAM and HOLLAND.—*Course of Exchange.*

	Uncertain Prices.	Certain Prices.
London	*rec.* 37 shillings Flemish	*for* 1 pound sterling.
Idem	*rec.* 12 florins current	*for* 1 pound sterling.
Breslaw	*rec.* 44 stivers banco	*for* 1 libra banco.
Dantzic	*rec.* 1 pound Flemish	*for* 372 groshen current.
France	*rec.* 54 grotes Flemish	*for* 3 francs.
Francfort	*giv.* 139 rixdollars	*for* 100 rix dollars current.
Geneva	*rec.* 90 grotes Flemish	*for* 1 crown current.
Genoa	*rec.* 83 grotes Flemish	*for* 1 pezza fuori di banco.
Hamburgh	*rec.* 33 stivers banco	*for* 1 marc lubs banco.
Idem	*rec.* 106 florins current	*for* 120 marcs lubs banco.
Leghorn	*rec.* 88 grotes Flemish	*for* 1 pezza of 8 reals.
Portugal	*rec.* 44 grotes Flemish	*for* 1 crusade of 400 reis.
Spain	*rec.* 89 grotes Flemish	*for* 1 ducat of exchange.
Venice	*giv.* 4 lire 18 soldi	*for* 1 florin banco.
Vienna	*rec.* 25 stivers banco	*for* 1 rixdollar current.

Amsterdam on London.

Reduce 356 pounds 17 shillings 6 pence sterling into florins, stivers, and penings banco, at the exchange of 38 shillings 2 grotes Flemish banco per pound sterling.

1 pound = 38 shill. 2 grotes
1 shilling = 12 grotes
40 grotes = 1 florin.

Rule.—Multiply 356 17 6 by 38 2, price of exchange, and by 12 grotes; divide the product by 40 grotes.

	356 17 6
38 2 × 12 =	458
	2848
	1780
	1424
for 10 shillings	229
for 5 ditto -	114 10
for 2 do. 6 pence	57 5
	40)163448 15(4086 4 6 result.

N. B. When the price of exchange consists of shillings Flemish only, multiply the price of exchange by three instead of 12, and divide the product by 10 instead of 40.

Amsterdam and Rotterdam on London.

Reduce 196 pounds 17 shillings 6 pence sterling into florins, stivers, and penings current, at the exchange of 12 florins 4 stivers current per pound sterling.

1 pound = 12 florins 4 stivers.

Rule.—Multiply 196 17 6 by 12 4, price of exchange.

		196 17 6
		12 4
		392
		196
for 4 stivers	-	39 4
for 10 shillings	-	6 2
for 5 ditto	-	3 1
for 2 ditto 6 pence		1 10 8
		2401 17 8 result.

Amsterdam on France.

Reduce 1056 francs 75 cents into florins, stivers, and penings banco, at the exchange of 54 grotes Flemish banco for 3 francs.

3 francs = 54 grotes
40 grotes = 1 florin.

Rule.—Multiply 1056 75 by 54, price of exchange, and divide the product by 120, fixed number.

	1056 75
	54
	4224
	5280
for 50 cents	27
for 25 cents	13½
	120)57064½(475 10 12 result.

Amsterdam on Genoa.

Reduce 572 pezze fuori di banco into florins and stivers banco, at the exchange of 85 grotes Flemish banco per pezza of 115 soldi fuori di banco.

1 pezza = 85 grotes
40 grotes = 1 florin.

Rule.—Multiply 572 by 85 grotes, and divide the product by 40 grotes.

The result is 1215 10.

Amsterdam on Hamburgh.

Reduce 3746 marcs 5 shillings 4 fenings lubs banco into florins, stivers, and penings banco, at the exchange of $34\frac{1}{2}$ stivers banco for 2 marcs lubs banco.

2 marcs = $34\frac{1}{2}$ stivers
20 stivers = 1 florin.

Rule.—Multiply 3746 5 4 by $34\frac{1}{2}$, price of exchange, and divide the product by 40, fixed number.

	3746 5 4
	$34\frac{1}{2}$
	14984
	11238
for $\frac{1}{2}$ -	1873
for 4 shillings	8 10
for 1 shilling	2 2 6
for 4 fenings	11 6
	40)$129248\frac{1}{2}$(3231 4 4 result.

Reduce 2854 marcs 8 shillings lubs banco into florins, stivers, and penings current, at the exchange of 106 florins current for 120 marcs lubs banco.

120 marcs = 106 florins.

Rule.—Multiply 2854 8 by 106, price of exchange, and divide the product by 120 marcs.

	2854 8
	106
	17124
	28540
for 8 shillings	53
	120)302577(2521 9 8 result.

The United States of America.

Moneys of exchange, and regulations.

A dollar = 100 cents.

Accounts are kept in dollars and cents.

Each dollar is rated at 4 shillings 6 pence sterling at par; therefore

40 dollars = 9 pounds sterling.

Course of Exchange.

Uncertain Prices. Certain Prices.

Amsterdam *rec.* 37 cents *for* 1 florin current.

Hamburgh *rec.* $33\frac{1}{2}$ cents *for* 1 marc lubs banco.

N. B. America exchanges with London at par, or at so much per cent. either above or under par. When the exchange is not at par, they reduce the sterling into dollars, and add, or deduct, according to the circumstance, the agio, that is, the difference between the par of exchange and the actual course.

Currencies, and their par in sterling.

A pound currency = 20 shillings or 240 pence.

In Georgia and South Carolina, a dollar is worth 4 shillings 6 pence currency; therefore

100 pounds currency = 100 pounds sterling.

In New England and Virginia, a dollar is worth 6 shillings currency; therefore

$133\frac{1}{3}$ pounds currency = 100 pounds sterling.

To reduce this currency into sterling, multiply by 3, and divide by 4.

In Delaware, Maryland, New Jersey, and Pennsylvania, a dollar is worth 7 shillings 6 pence currency; therefore

$166\frac{2}{3}$ pounds currency = 100 pounds sterling.

To reduce this currency into sterling, multiply by 3, and divide by 5.

In New York and North Carolina, a dollar is worth 8 shillings currency; therefore

$177\frac{7}{9}$ pounds currency = 100 pounds sterling.

To reduce this currency into sterling, multiply by 9, and divide by 16.

N. B. The several provincial currencies above mentioned are abolished in the United States of America, and the accounts kept in those moneys are not admitted in the courts of justice: they are still used, however, by the force of habit, in certain commercial transactions.

America on London.

Reduce 173 pounds 17 shillings 6 pence sterling into dollars and cents at par.

9 pounds = 40 dollars.

Rule.—Multiply 173 17 6 by 40 dollars, and divide the product by 9 pounds.

	173 17 6
	40
	6920
for 10 shillings	20
for 5 ditto	10
for 2 ditto 6 pence	5
	9)6955(772 $77\frac{7}{9}$ result.

To prove this operation, multiply 772 $77\frac{7}{9}$ by 9, and divide the product by 40.

America on Amsterdam.

Reduce 839 florins 15 stivers current into dollars and cents, at the exchange of 37 cents per florin current.

1 florin = 37 cents
100 cents = 1 dollar.

Rule.—Multiply 839 15 by 37, price of exchange, and divide the product by 100 cents.

	839 15
	37
	5873
	2517
for 10 stivers	$18\frac{1}{2}$
for 5 do.	$9\frac{1}{4}$
	1,00)310,$70\frac{3}{4}$(310 $70\frac{3}{4}$ result.

To prove this operation, multiply 310 $70\frac{3}{4}$ by 100 cents, and divide the product by 37, price of exchange.

America on Hamburgh.

Reduce 1236 marcs 12 shillings lubs banco into dollars and cents, at the exchange of $33\frac{1}{2}$ cents per marc lubs banco.

1 marc = $33\frac{1}{2}$ cents
100 cents = 1 dollar.

Rule.—Multiply 1236 12 by $33\frac{1}{2}$, price of exchange, and divide the product by 100 cents.

1236 12
$33\frac{1}{2}$

3708

	3708
for $\frac{1}{2}$	618
for 8 shillings	$16\frac{3}{4}$
for 4 ditto	$8\frac{3}{8}$

1,00)414,31$\frac{1}{8}$(414 31$\frac{1}{8}$ result.

To prove this operation, multiply 414 31$\frac{1}{8}$ by 100 cents, and divide the product by 33$\frac{1}{2}$, price of exchange.

EAST INDIES.

Moneys of Exchange.

Bombay.

A rupee = 4 quarters or 400 reis
A quarter = 100 reis.

Calcutta.

A rupee = 16 annas or 192 pices
An anna = 12 pices
100 sicca rupees = 116 current rupees.

Madras.

A pagoda = 36 fanams or 288 pices.
A fanam = 8 pices.

Course of Exchange

Ordered to be adopted for the adjustment of the Calcutta customs.

	Uncertain Prices.	Certain prices.
Bombay	*rec.* 2 shillings 6 pence	*for* 1 rupee.
Calcutta	*rec.* 2 shillings 8 pence	*for* 1 sicca rupee.
Madras	*rec.* 8 shillings 9 pence	*for* 1 star pagoda.

Table of exchange.

	Coins.	Exchange.
Great Britain	*giv.* 1 pound sterling	*for* 10 sicca rupees.
Denmark	*giv.* 1 rix dollar	*for* $2\frac{1}{4}$ ditto.
France	*giv.* 24 livers	*for* 10 ditto.
Ditto	*giv.* 48 Mauritius livres	*for* 10 ditto.
Spain	*giv.* 1 hard dollar	*for* $2\frac{1}{4}$ ditto.
Portugal	*giv.* 1000 reis	*for* $2\frac{3}{4}$ ditto.
China	*giv.* 1 tale	*for* $3\frac{1}{4}$ ditto.
Madras	*giv.* 1 star pagoda	*for* $3\frac{3}{4}$ ditto.
America	*giv.* 1 dollar	*for* $2\frac{1}{4}$ ditto.

WEST INDIES ON LONDON.

Moneys of Exchange.

A pound currency = 20 shillings or 240 pence.

Accounts are kept in pounds, shillings, and pence currency.

140 pounds currency = 100 pounds sterling.

Reduce 573 pounds 12 shillings 6 pence sterling into pounds, shillings, and pence curnency, at the exchange of 140 pounds currency for 100 pounds sterling.

100 pounds sterling = 140 pounds currency.

Rule.—Multiply 573 12 6 by 140, price of exchange, and divide the product by 100 pounds.

	573 12 6
	140
	22920
	573
for 10 shillings	70
for 2 do. 6 pence	17 10

1,00)803,07 10(803 1 6 result.
20

1,50
12

6,00

To prove this operation, multiply 803 1 6 by 100 pounds, and divide the product by 140, price of exchange.

Arbitration of EXCHANGES is a calculation, by combining the rates of exchange of two or more places, to draw therefrom that which shall be the most advantageous to remit or draw on. If bills remained always at par, or if the course of exchange was susceptible of being regulated with accuracy, there would be no such thing as an advantage to be obtained in one more than the other. The data to go upon are easily to be obtained, as the current prices are always published at short intervals.

The following examples will illustrate the nature of this subject.

London and Amsterdam.

Proportional Exchange.

	Quotation At London.	Quotation from Amsterdam.
On Amsterdam	37 3	
Genoa	45	$83\frac{1}{2}$
Hamburgh	35	34
Leghorn	$48\frac{1}{2}$	90
Lisbon	62	$44\frac{1}{2}$
Madrid	$34\frac{1}{2}$	$88\frac{1}{4}$
Paris	25 15	$53\frac{1}{2}$

Observation.—London gives the certain price to Amsterdam; that is, 1*l.* sterling for so many shillings Flemish banco, more or less; therefore, when London remits to Amsterdam, that place through which the highest course of exchange can be obtained is to be preferred, because more shillings Flemish will be received in exchange for one pound sterling. On the contrary, when London has to draw upon Amsterdam, that place should be chosen which furnishes the lowest course, because less shillings Flemish will be given in exchange for a pound sterling.

If you include the charges in the calculation, insert, for an indirect remittance, 100 in the divisor, and 100 less the charges in the dividend; and, for an indirect draft, place 100 in the divisor, and 100 more the charges in the dividend.

N. B. The above quotations are successively combined in the following arbitrations to ascertain the advantage which may be derived from the comparison of the differen t proportional exchanges.

London and Amsterdam through Genoa.

A bill on Genoa taken in London at 45 pence sterling per pezza of $5\frac{3}{4}$ lire fuori di banco is remitted to Amsterdam, and negotiated at $83\frac{1}{2}$ grotes Flemish banco per pezza fuori di banco; what is the proportional exchange between London and Amsterdam?

1 pound sterling	=	240 pence
45 pence	=	1 pezza
1 pezza	=	$83\frac{1}{2}$ grotes
12 grotes	=	1 shilling Flemish.

Rule.—Multiply 20, fixed number, by the course of exchange between Amsterdam and Genoa; and divide the product by the course of London on Genoa, that is,

$$\frac{20 \times 83\frac{1}{2}}{45} = 37\ 1\tfrac{1}{3}.$$

London on Amsterdam through Hamburgh.

A bill on Hamburgh taken in London at 35 shillings

Flemish banco per pound sterling is remitted to Amsterdam, and negotiated at 34 stivers banco for 2 marcs lubs banco: what is the proportional exchange between London and Amsterdam?

1 pound sterling	=	35 shillings Flemish
8 shillings Flemish	=	3 marcs
2 marcs banco	=	34 stivers banco
6 stivers	=	1 shilling Flemish.

Rule.—Multiply the course of exchange between London and Hamburgh by the course of Amsterdam on Hamburgh, and divide the product by 32, fixed number, that is, $\frac{35 \times 34}{32} = 37\ 2\frac{1}{4}$.

London and Amsterdam through Leghorn.

A bill on Leghorn taken in London at $48\frac{1}{2}$ pence sterling per pezza of 8 reals is remitted to Amsterdam, and negotiated at 90 grotes Flemish banco per pezza of 8 reals: what is the proportional exchange between London and Amsterdam?

1 pound sterling	=	240 pence
$48\frac{1}{2}$ pence	=	1 pezza
1 pezza	=	90 grotes
12 grotes	=	1 shilling Flemish.

Rule.—Multiply 20, fixed number, by the course of exchange between Amsterdam and Leghorn; and divide the product by the course of London on Leghorn.

$48\frac{1}{2}$	20
2 fraction	90
97 div.	1800
	2 fraction
	97)3600(37 $1\frac{1}{3}$

London and Amsterdam through Lisbon.

A bill on Lisbon taken in London at 62 pence sterling per milreis is remitted to Amsterdam, and negotiated at $44\frac{1}{2}$ grotes Flemish banco per crusade of 400 reis: what is the proportional exchange between London and Amsterdam?

1 pound sterling	=	140 pence.
62 pence	=	1000 reis
400 reis	=	$44\frac{1}{2}$ grotes
12 grotes	=	1 shilling Flemish.

Rule.—Multiply 50, fixed number, by the course of exchange between Amsterdam and Lisbon; and divide the product by the course of London on Lisbon, that is, $\frac{50 \times 44\frac{1}{2}}{62} = 35\ 10\frac{2}{3}$.

London and Amsterdam through Madrid.

A bill on Madrid taken in London at $34\frac{1}{2}$ pence sterling per dollar of exchange is remitted to Amsterdam, and negotiated at $88\frac{1}{4}$ grotes Flemish banco per ducat of exchange: what is the proportional exchange between London and Amsterdam?

1 pound sterling	=	240 pence
$34\frac{1}{2}$ pence	=	1 dollar
375 dollars	=	272 ducats
1 ducat	=	$88\frac{1}{4}$ grotes
12 grotes	=	1 shilling Flemish.

Rule.—Multiply 1088, fixed number, by the course of exchange between Amsterdam and Madrid; and divide the product by 75, fixed number, multiplied by the course of London on Madrid.

75	1088
$34\frac{1}{2}$	$88\frac{1}{4}$
300	8704
225	8704
$37\frac{1}{2}$	272
$2587\frac{1}{2}$	96016
2 fraction	2 fraction
5175 div.	5175)192032(27 $1\frac{5}{16}$ result.

London and Amsterdam through Paris.

A bill on Paris taken in London at 25 livres 15 sols tournois per pound sterling is remitted to Amsterdam, and negotiated at $53\frac{1}{2}$ grotes Flemish banco for 3 francs: what is the proportional exchange between London and Amsterdam?

1 pound sterling	=	$25\frac{3}{4}$ livres tournois
81 livres tournois	=	80 francs
3 francs	=	$53\frac{1}{2}$ grotes
12 grotes	=	1 shilling Flemish.

Rule.—Multiply 20, fixed number, by the course of exchange between London and Paris, and by the course of Amsterdam on Paris; divide the product by 729, fixed number: that is $\frac{20 \times 25\frac{3}{4}}{729} = 37\ 9\frac{1}{2}$.

Recapitulation of the proportional exchange between London and Amsterdam.

Though	Genoa it comes out at	37	$1\frac{1}{3}$
	Hamburgh - -	37	$2\frac{1}{4}$
	Leghorn - -	37	$1\frac{1}{3}$
	Lisbon will answer to draw	35	$10\frac{2}{3}$
	Madrid	37	$17\frac{1}{16}$
	Paris will answer to remit	37	$9\frac{1}{2}$
Direct course between London and Amsterdam.		37	3

Application to remit.—It appears by the comparison of the above-mentioned exchanges, that the proportional exchange upon Paris is the highest, and consequently, that it would be more advantageous to remit to Amsterdam by that place than by either of the others, or by a direct bill. Such remittance would establish an indirect course of 37 $9\frac{1}{2}$, instead of the direct, 37 3; so that a merchant would receive 37 shillings $9\frac{1}{2}$ grotes Flemish in exchange for one pound sterling.

37 3 direct course: 37 $9\frac{1}{2}$			
indirect course : : 100 :			101 9 1
Less for charges, at $\frac{3}{4}$ per cent.	0 15 0	}	1 9 1
Advantages resulting from the arbitration	0 14 1		
			100 0 0

Application to draw.—If a merchant at London had to value on Amsterdam, instead of drawing directly, he would order his correspondent at Amsterdam to take a bill on Lisbon at $44\frac{1}{2}$, and either to remit it thither to provide for drafts from London upon Lisbon at 62, or to remit it to London to be negotiated at the same price. Such operation would establish an indirect course of 35 $10\frac{2}{3}$, instead of the direct, 37 3; so that a merchant

would give only 35 shillings $10\frac{2}{3}$ grotes Flemish for one pound sterling.

37 3 direct course: 35 $10\frac{2}{3}$						
indirect course : : 100*l.*:				96	6	10
Add for charges, at $\frac{3}{4}$ per cent.	0	15	0			
Advantages resulting from the arbitration	2	18	2	3	13	2
				100	0	0

London and Genoa.

Proportional exchange.

	Quotation at London.	Quotation from Genoa.
On Genoa - -	46	
Amsterdam - -	37 4	$84\frac{7}{8}$
Hamburgh - -	35 4	$46\frac{1}{4}$
Leghorn - - -	50	$124\frac{1}{2}$
Lisbon - - -	$61\frac{1}{2}$	765
Madrid - - -	$34\frac{3}{4}$	660
Paris - - -	25 2	$94\frac{5}{8}$

Observation.—London gives the uncertain price to Genoa; that is, 46 pence sterling, more or less, for one pezza fuori di banco; therefore, when London remits to Genoa, that place through which the lowest course of exchange can be obtained is to be preferred, because less pence will be given in exchange for one pezza. On the contrary, when London has to draw upon Genoa, that place should be chosen which furnishes the highest course, because more pence will be received in exchange for a pezza.

If you include the charges in the operation, insert, for an indirect remittance, 100 less the charges in the divisor, and 100 in the dividend; and, for an indirect draft, place 100 more the charges in the divisor, and 100 in the dividend.

N. B. The above quotations are successively combined in the following arbitrations to ascertain the advantage which may be derived from the comparison of the different proportional exchanges.

London and Genoa through Amsterdam.

A bill on Amsterdam taken in London at 37 shillings 4 grotes Flemish banco per pound sterling is remitted to Genoa, and negotiated at $84\frac{7}{8}$ grotes Flemish banco per pezza of $5\frac{3}{4}$ lire fuori di banco: what is the proportional exchange between London and Genoa?

1 pezza = $84\frac{7}{8}$ grotes
12 grotes = 1 shilling Flemish
$37\frac{1}{3}$ shill. Flemish = 1 pound sterling
1 pound sterling = 240 pence.

Rule.—Multiply 20, fixed number, by the course of exchange between Genoa and Amsterdam; and divide the product by the course of London on Amsterdam.

$37\frac{2}{3}$	20
3 fraction	$84\frac{7}{8}$
112 div.	1680
	$17\frac{1}{2}$
	$1697\frac{1}{2}$
	3 fraction
	112)$5092\frac{1}{2}$($45\frac{1}{2}$ result.

London and Genoa through Hamburgh.

A bill on Hamburgh taken in London at 35 shillings 4 grotes Flemish banco per pound sterling is remitted to Genoa, and negotiated at $46\frac{3}{4}$ solid fuori di banco per marc lubs banco: what is the proportional exchange between London and Genoa?

1 pezza = 115 soldi
$46\frac{1}{4}$ soldi = 1 marc banco
3 marcs = 8 shillings Flemish
$35\frac{2}{6}$ shill. Flem. = 1 pound sterling
1 pound sterling = 240 pence sterling.

Rule.—Divide 73600, fixed number, by the course of exchange between London and Hamburgh, multiplied by the course of Genoa on Hamburgh.

$35\frac{2}{6}$	73600
6 fraction	6 fraction.
212	9805)441600(45 result.
$46\frac{1}{4}$	49400
	375
1272	
848	
53	
9805 div.	

London and Genoa through Leghorn.

A bill on Leghorn taken in London at 50 pence sterling per pezza of 8 reals is remitted to Genoa, and negotiated at $124\frac{1}{2}$ soldi fuori di banco per pezza of 8 reals: what is the proportional exchange between London and Genoa?

1 pezza fuori di banco = 115 soldi ditto
$124\frac{1}{2}$ soldi ditto = 1 pezza of 8 reals
1 pezza of 8 reals = 50 pence sterl.

Rule.—Multiply 115, fixed number, by the course of exchange between London and Leghorn; and divide the product by the course of Genoa on Leghorn.

$124\frac{1}{2}$	115
2 fraction	50
249 div.	5750
	2 fraction
	249)11500($46\frac{3}{16}$ result.
	1540
	46

London and Genoa through Lisbon.

A bill on Lisbon taken in London at $61\frac{1}{2}$ pence sterling per milreis is remitted to Genoa, and negotiated at 765 reis per pezza of 115 soldi fuori di banco: what is the proportional exchange betweeen London and Genoa?

1 pezza = 765 reis
1000 reis = $61\frac{1}{2}$ pence.

Rule.—Multiply the course of exchange between Genoa and Lisbon by the course of London on Lisbon; and divide the product by 1000, fixed number.

765
$61\frac{1}{2}$
765
4590
$382\frac{1}{2}$
1,000) 47,0474$\frac{1}{2}$($7\frac{1}{21}$ result.

London and Genoa through Madrid.

A bill on Madrid taken in London at $34\frac{3}{4}$ pence sterling per dollar of exchange is remitted to Genoa, and negotiated at 660 maravedis per gold crown: what is the proportional exchange between London and Genoa?

1 pezza	=	115 soldi
214 soldi	=	1 gold crown
1 gold crown	=	660 maravedis
272 maravedis	=	1 dollar
1 dollar	=	$34\frac{3}{4}$ pence.

Rule.—Multiply 115, fixed number, by the course of exchange between Genoa and Madrid, and by the course of London on Madrid; divide the product by 58208, fixed number.

```
      115
      660
     ----
     6900
    690
   ------
    75900
      34 3/4
   ------
   303600
  227700
    56925
  -------
58208)2637525(45 5/16 result.
   309205
    18165
```

London and Genoa through Paris.

A bill on Paris taken in London at 25 livres 2 sols tournois per pound sterling is remitted to Genoa, and negotiated at $94\frac{7}{8}$ sols in francs per pezza of 115 soldi fuori di banco: what is the proportional exchange between London and Genoa?

1 pezza	=	$94\frac{7}{8}$ sols
20 sols	=	1 franc
80 francs	=	81 livres tournois
$25\frac{1}{10}$ livres tournois	=	1 pound sterling
1 pound sterling	=	240 pence sterling.

Rule.—Multiply 243, fixed number, by the course of exchange between Genoa and Paris; and divide the product by 20, fixed number, multiplied by the course of London on Paris.

```
  20          243
  25 1/10      94 7/8
  ----        ------
 502 div.     972
            2187
              121 4/8
               60 6/8
               30 3/8
          ----------
 502)23054 5/8(45 15/16 result.
       2974
        464
```

Recapitulation of the proportional exchange between London and Genoa.

Through Amsterdam it comes out at	$45\frac{1}{2}$
Hamburgh will answer to remit	45
Leghorn	$46\frac{3}{16}$
Lisbon will answer to draw	$47\frac{1}{21}$
Madrid	$45\frac{5}{16}$
Paris	$45\frac{15}{16}$
Direct course between London and Genoa	46

Application to remit.—It appears by the comparison of the above-mentioned exchanges, that the proportional exchange upon Hamburgh is the lowest, and consequently, that it would be more advantageous to remit to Genoa by that place, than by either of the others, or by a direct bill. Such remittance would establish an indirect course of 45, instead of the direct 46; so that a merchant would give only 45 pence in exchange for one pezza fuori di banco.

46 direct course : 45 indirect course : : 100*l*.				97	16	6
Add for charges, at $\frac{3}{4}$ per cent.	0	15	0	2	3	6
Advantages resulting from the arbitration	1	8	6			
				100	0	0

Application to draw.—If a merchant at London had to value on Genoa, instead of drawing directly, he would order his correspondent at Genoa to take a bill on Lisbon at 765, and either to remit it thither to provide for drafts from London upon Lisbon at $61\frac{1}{4}$, or to remit it to London to be negotiated at the same price. Such operation would establish an indirect course of $47\frac{1}{21}$, instead of the direct 46; so that a merchant would receive $47\frac{1}{21}$ pence in exchange for a pezza.

46 direct course: $47\frac{1}{21}$ indirect course : : 100*l*.				102	5	7
Less for charges, at $\frac{3}{4}$ per cent.	0	15	0	2	5	7
Advantage resulting from the arbitration	1	10	7			
				100	0	0

Exchange signifies also a place in most considerable trading cities, wherein the merchants, negotiants, agents, bankers, brokers, interpreters, and other persons concerned in commerce, meet on certain days, and at certain times, to confer and treat together of matters relating to exchanges, remittances, payments, adventures, assurances, freightments, and other mercantile negotiations, both by sea and land. These assemblies are held with so much exactness, that the absence of a merchant, &c. makes him suspected of drawing to a failure or bankruptcy, as not being able to stand the Change. The most considerable exchanges in Europe, are those of Amsterdam, and that of London, called the Royal Exchange.

Exchange of church livings, is where two persons having procured licence from the ordinary to treat of and exchange, do, by one instrument in writing, agree to exchange their benefices, being both spiritual, and in order thereunto resign them into the hands of the ordinary: such exchange being executed, the resignations are good. Wats. c. 4. These exchanges are now seldom used.

EXCHEQUER. This, which is a court of law and equity, is a very ancient court of record, established by William the Conqueror, as a part of the aula regis, though regulated and reduced to its present state by Ed. I. and intended principally to order the revenues of the crown, and to recover the king's debts and duties.

The court consists of two divisions, viz. the receipt of the exchequer, which manages the royal revenue: and

the judicial, which is again subdivided into a court of equity, and a court of common law.

The court of equity is held in the exchequer, before the lord treasurer, the chancellor of the exchequer, the chief baron, and three *puisne'* barons. The primary and original business of this court was to call the king's debtors to account, by bill filed by the attorney-general, and to recover any lands, tenements, or hereditaments, goods, chattels, or other profits or benefits, belonging to the crown.

This court, which was established merely for the benefit of the king's accountant, is thrown open; and now, by suggestion of privilege, any person may be admitted to sue here, as well as the king's accountant.

An appeal from the equity side of this court, lies immediately to the house of peers; but from the common law side, pursuant to 31 Ed. III. c. 12. a writ of error must first be brought into the court of exchequer chamber, whence, in the dernier resort, there lies an appeal to the house of lords.

Chancellor of the EXCHEQUER. See CHANCELLOR.

EXCHEQUER CHAMBER has no original jurisdiction, but is merely a court of appeal, to correct the errors of other jurisdictions; and consists of the lord chancellor, the lord treasurer, with the justices of the king's-bench and common-pleas. In imitation of this, a second court of exchequer chamber was erected by 27 Eliz. c. 8. consisting of the justices of the common-pleas, and the barons of the exchequer; before whom writs of error may be brought, to reverse judgments in certain suits commenced originally in the court of king's-bench. Into the exchequer chamber, are sometimes adjourned from the other courts, such causes, as the judges upon argument find to be of great weight and difficulty, before any judgment is given upon them to the court.

EXCHEQUER BILLS. Bills of credit, issued by the authority of parliament, payable with interest out of the produce of a particular tax, or more frequently out of the supplies to be granted in a future session. The sum of 2,750,000*l.* is usually raised in this manner on credit of the malt tax, and tax on personal estates, although it is well known that these taxes never produce so much, the deficiency being always made good out of the next supplies. The sum to be issued out of the produce of the consolidated fund is likewise usually raised by these bills, charged upon the growing produce of the surplus of the said fund; also other sums for ordinary and extraordinary expenses, by bills charged upon the first supplies of the next session; so that of late years the total amount of outstanding exchequer bills has usually been about ten millions. The bank, since 1706, have contracted with government for the circulation of these bills at a certain premium. The interest they carry has been at various rates, from *L.* 7 : 12 to 3 per cent.; those at present in circulation bear interest at the rate of three pence halfpenny a day per cent. which is computed up to the day of sale, from the respective dates of the bills. They are generally for 100*l.* each, but many of those issued on the vote of credit are for *l.*1000, and they have sometimes been made out for much larger sums: they are numbered arithmetically, and registered accordingly; for the purpose of paying them off in a regular course. They are paid at the exchequer bill office, and the time of payment is notified by advertisement.

The daily transactions between the bank and the exchequer are chiefly carried on by bills of 1000*l.* each, which are deposited by the bank in the exchequer to the amount of the sums received by them on government account; the bank notes and cash thus received by the bank being retained by them, as the detail part of the money-concerns of government is all transacted at the bank. The instalments on loans are paid into the receipt of the exchequer by these exchequer bills of 1000*l.* each, which are received again by the bank as cash, either for the amount of dividends due, or in re-payments of advances; and as, while deposited in the exchequer, they are considered merely as a pledge or security, they of course continue to bear interest, till the advance on which the bank first received them is paid off.

In October, 1796, the 5 per cent. exchequer bills, issued on the vote of credit, being at a considerable discount, it was thought proper to fund them; and the terms agreed upon were as follows:—The holders to be entitled for every 100*l.* to either of the following capitals:

l.	*s.*	*d.*	
176	19	$9\frac{3}{4}$	in the 3 per cents.
137	18	$7\frac{1}{4}$	in the 4 per cents.
118	6	$10\frac{1}{4}$	in the 5 per cents.

The amount of the bills thus funded was *l.* 33,870, and the capital stock created in the different funds, *l.* 2,374,333 14 8.

In November, 1801, it was again found necessary to fund a considerable part of the outstanding exchequer bills, which was effected on the following conditions: for each 100*l.* principal to receive the undermentioned proportions of stock:

l.		Estimated value. *l.*	*s.*	*d.*
25	Three per cent. consols	17	1	$10\frac{1}{2}$
25	Three per cent. reduced	16	16	$10\frac{1}{2}$
50	Four per cent. consols	42	7	6
25	New 5 per cents.	24	15	0
	1*s.* 9*d.* Long annuity	1	14	4
		l. 102	15	7

And the proprietors to have the liberty of subscribing 50*l.* additional in money for every 100*l.* they held in bills, the money thus raised to be applied in paying off the sum of about 2,400,000*l.* in exchequer bills in the possession of the bank. The amount of the bills funded and redeemed was 8,910,450*l.*

As there is always a considerable sum outstanding in exchequer bills, the interest paid thereon forms a constant addition to the annual charge of the funded debt; the amount paid for interest on exchequer bills in the years 1803, 1804, and 1805, respectively, was as follows:

	l.	*s.*	*d.*
1803 . .	801 787	10	$5\frac{1}{2}$
1804 . .	624.859	18	10
1805 . .	1.478.316	3	$3\frac{1}{2}$

The premium or discount at which exchequer bills sell, depends on the proportion which the interest payable on them bears to the interest produced by the public funds according to their current prices.

Exchequer bills, though the same in their nature and

solidity, differ in their origin from navy bills in this, that they are issued in anticipation of revenue, and circulated by the bank of England to raise money. During the recess of parliament, there is a sum left to the credit of the chancellor of the exchequer, to serve in cases of exigency. The bank makes advances to the amount voted, for which the exchequer issues bills. There is a standing contract between goverment and the bank for the trouble and expense attending the issue and circulation of these bills. Notice is given by public advertisement, and the payment is made at the exchequer-bill office Westminster.

EXCHEQUER, *black book of the*, a book containing a description of the court of England in 1175, and its officers, with their ranks, wages, privileges, perquisites, &c. also the revenues of the crown, both in money and cattle. Here we find that for one shilling as much bread might be bought as would serve 100 men a whole day; that the price of a fat bullock was only 12 shillings, and a sheep less than four.

EXCISE, one of the principal branches of the public revenue, consisting of inland duties, or taxes on articles manufactured or consumed, whereas the duties of customs are paid on goods brought into or carried out of the country. Excise duties are of very ancient date; they were numerous among the Romans, and were established in Italy, Spain, France, and Holland, long before they were known in this country. The first attempt to introduce this species of taxation into England was in the year 1626, but it was not actually established till 1643, when the long parliament laid an excise duty on beer, ale, and other liquors, with a solemn declaration that at the end of the war all excises should be abolished. The example was immediately followed by the king and parliament of Oxford, who established similar excise duties, and the contest continuing longer than was expected, this mode of levying money was extended to bread, meat, salt, and many other necessary articles. The excise on bread and meat was afterwards repealed, but the duties on beer and ale were continued, and after the Restoration were granted to Charles 2d, during his life; from whose death they were continued, under the title of the *temporary excise*, to the different sovereigns, during their respective lives, as a part of the civil list revenue; but they are now placed on the same footing as all the other permanent taxes, being made perpetual, and the produce carried to the consolidated fund. The *hereditary excise* was a duty of fifteen pence per barrel upon beer and ale, and a proportionate sum upon other liquors sold in the kingdom, and was granted to Charles 2d, his heirs and successors for ever, as a compensation for the profits of the feudal privileges of wardship and purveyance then abolished by act of parliament. These two branches, which comprehend all the excise duties existing at the Revolution, produced on an average 610,486*l.* yearly. During the reign of William 3d, the excise was extended to salt, additional duties were laid on beer and ale, and an excise duty on malt, which has since been granted annually, was established. In the reign of queen Anne, candles, hides and skins, vellum and parchment, paper and pasteboards, soap, starch, hops, and some other articles, were subjected to excise duties. In the reign of George 1st, the excise duties, with all other taxes which had been granted for terms of years, were made perpetual, a duty was laid on wrought plate, and the principal part of the duties on tea, coffee, and chocolate, was transferred from the customs to the excise. During the reign of George 2d, considerable additions were made to the excise duties, by licences, a duty on glass, and new duties on spirituous liquors, coffee, chocolate, and malt; an attempt was made by sir R. Walpole to transfer the duties on wines and tobacco from the customs to the excise, but the measure being thought introductory to a general excise, it experienced great opposition, and was abandoned. Since that period, numerous additional duties have been imposed on all the articles subject to the excise, with which the increased consumption caused by the progress of population and luxury, has rendered this source of revenue so productive, that it is not surprising those who have had the management of the public finances should have become partial to it, though it has always been an obnoxious mode of taxation to the public. The total gross amount raised in England by excise duties, in the year ending 5th of January, 1805, will appear by the following account.

Auctions	*l.* 181,126
Beer	2,878,830
Bricks and tiles	226,203
Candles	299,479
Coachmakers	274
Cocoa nuts and coffee	86,801
Cyder and perry	19,868
Glass	293,640
Hides and skins	281,210
Hops	432,178
Licences	290,094
Malt	1,147,937
Metheglin or mead	189
Paper	317,380
Printed goods	686,971
Salt	1,097,151
Soap	526,028
Spirits, British	1,267,423
Ditto, foreign	1,482,052
Starch	54,196
Sweets	26,985
Tea	968,199
Tobacco and snuff	187,302
Verjuice	77
Vinegar	23,754
Wine	569,770
Wire	8,272
Total consolidated duties	*l.* 13,353,389

Temporary war taxes.

Malt	2,878,254
Wine	435,785
Sweets	4,039
Spirits, British	621,566
Ditto, foreign	736,451
Tea	1,010,842
Total war taxes	*l.* 5,686,937

Annual duties.

Tobacco and snuff	430,148
Malt, additional	927,534
Malt, old	587,635
Total annual duties	*l.* 1,945,317

These sums, making together upwards of twenty millions, are, however, subject to several deductions, such as the expenses of collection, the drawbacks allowed on exportation, bounties on beer, British spirits, and fish exported, pensions to the duke of Grafton and others charged on this particular branch of the public revenue, sundry allowances and repayments.

Abstract of the total receipt.

Balance remaining on the 5th of January, 1804	15,448
Received on consolidated duties	13,353.389
Temporary war taxes	5,686,937
Annual duties	1,945,317
	l. 21,001,092
By charges of management	545,256
taxes repaid to officers	31,729
exports	801,028
allowances	60,700
bounties on fish exported, &c.	20,002
overcharges, repayments, &c.	38,180
annual payment to officers of the late wine licence office, and of the late salt duties	12,214
pensions	14,000
payments into the exchequer	19,448,148
balance remaining on the 5th Jan. 1805	29,837
	l. 21,001,092

The articles on which excise duties are collected in Scotland are nearly the same as in England, with some little variations in the rates at which the duties are imposed; the produce for the year ending 5th of January, 1805, was as follows:

Abstract of the total receipt.

Balance remaining on the 5th January, 1804	62,889
Received on permanent duties	1,049,324
——— temporary war taxes	328,715
——— annual duties	106,629
	l. 1,547,557
By charges of management	126,070
exports	82,538
allowances	10,462
disbursements out of the net produce	98,075
remittances to London	1,158,000
balance remaining on 5th January, 1805	72,412
	l. 1,547,557

Produce of the duties of excise in Ireland for the year ending 5th January, 1805.

On auctions	5,454
glass bottles	1,471
coffee	487
hides, leather, &c.	38,541
On malt	323,628
paper-hangings	1,376
writing-paper and parchment	10,940
wines, mead, and vinegar (home-made)	545
wines, foreign	48,895
sugar	1,533
strong waters	736,757
tobacco	144,122
licences	71,324
	l. 1,384,873

In England the excise duties are collected at an expense of only 2*l.* 16*s.* 1*d.* per cent. on the gross revenue, or 3*l.* 4*d.* per cent. on the net produce; but the expense of collection in Scotland amounts to 7*l.* 8*s.* 6*d.* per cent. on the gross revenue, or 3*l.* 10*s.* 6*d.* per cent. on the net produce. In Ireland the management of the excise duties is united with the customs, and the expense of the whole amounts to 11*l.* 3*s.* 3*d.* per cent. on the net revenue.

Excise Laws. For more easily levying the revenue of the excise, the kingdom of England and Wales is divided into about fifty collections, some of which are called by the names of particular counties, others by the names of great towns; where one county is divided into several collections, or where a collection comprehends the contiguous parts of several counties, every such collection is subdivided into several districts, within which there is a supervisor; and each district is again subdivided into outrides and footwalks, within each of which there is a gauger or surveying officer.

The commissioners or sub-commissioners, in their respective circuits and divisions, shall constitute, under their hands and seals, so many gaugers as they shall find needful.

Arrears of duties.—By several acts of parliament, all articles in the possession of persons subject to the excise laws, together with all the materials and utensils of whatsoever description, are made liable for the arrears of duties, whether these be single or double duties; and if a trader, being in arrears for the single duties, becomes a bankrupt, and is convicted after the assignment of his effects, the double duties are a lien upon the exciseable commodities, utensils, and materials in the hands of his assignees, and the commissioners or magistrates may authorize the penalty to be levied upon all such commodities, and all the materials, preparations, utensils, and vessels for making thereof, in the custody of the bankrupt, or any person or persons in trust for him. 2 Doug. 411.

Bonds, for the exportation of exciseable commodities, are to be taken by officers of excise, and they are to be given generally upon all exciseable articles, at the place where exported.

Forgery of any stamps, licences, certificates, permits, or any other excise documents, is by various statutes made a capital felony.

Licences.—In all cases where licences are required, the licence will only sanction the business carried on in that particular place for which such licence was granted; but when the business is carried on by partners, one licence will be sufficient to cover the firm.

Officers of excise.—The officers of excise are to be appointed, and may be dismissed, replaced, or altered, by the commissioners, under their hands and seals; their salaries are allowed and established by the treasury; and by 1 W. & M. c. 24. s. 15. if it is proved by two witnesses, that any officer has demanded or taken any money, or other reward whatever, except of the king, such offender shall forfeit his office.

By several statutes, no process can be sued out against any officer of excise, for any act done in the execution of his office, until one month after notice given, specifying the cause of action, and the name and abode of the person who is to begin, and the attorney who is to conduct the action; and within one month after such notice, the officer may tender amends, and plead such tender in bar; and having tendered insufficient or no amends, he may, with leave of the court, before issue joined, pay money into court.

Officers of excise are empowered to search, at all times of the day, entered warehouses, or places for tea, coffee, &c. But private houses can only be searched upon oath of the suspicion before a commissioner or justice of peace, who can by their warrant authorize a search.

Permits. Persons dealing in exciseable commodities are entitled to permits for removing the same to different places in certain quantities, and under certain regulations. These permits are written upon a peculiar species of paper, manufactured expressly for the purpose; and by 23 Geo. III. c. 70. s. 11. no permit paper is to be delivered out before it shall be filled up agreeably to the request note of a trader; and officers knowingly granting any false permit, making false entries in the counterpart thereof, or receiving any commodities into stock with a false or forged permit, are to be transported for seven years.

Samples.—Officers of excise are, by various acts, empowered to take samples of exciseable commodities, paying the prices therein regulated for the same.

Seizures.—When an officer makes a seizure of any spirits, or other articles, he must lay his hand on the casks, vessels, &c. so seized, and declare that he seizes such spirits, &c. and the casks or vessels containing the same, for the use of his majesty and of himself; but if the officer happens to be alone when he makes such seizure, he must afterwards, in the presence of witnesses, again lay his hand on such cask, vessel, &c. and repeat the former declaration of seizure.

All informations on seizures must be laid in the names of the officers making the same.

By 41 Geo. III. c. 96. commissioners of excise are empowered to make restitution of exciseable goods.

Scales and weights.—By various acts of parliament, traders subject to the excise laws are to keep just and sufficient scales and weights, under penalty of 100*l.* for every such offence, and the scales and weights may be seized by the officer.

Traders, manufacturers, and dealers liable to excise duties, are to assist the officers in weighing stock; and forcibly obstructing, or using any art or contrivance to prevent or impede the officers from taking a true account incurs a penalty of 100*l.*

EXCLAMATION, in rhetoric, a figure that expresses the violent and sudden breaking out, and vehemence of any passion. Such is that in the second book of Milton's Paradise Lost:

> O unexpected stroke, worse than of death!
> Must I thus leave thee, Paradise? Thus leave
> Thee, native soil; these happy walks and shades,
> Fit haunt of gods?

EXCLUSION, *or bill of exclusion*, a bill proposed about the close of the reign of king Charles II. for excluding the duke of York, the king's brother, from the throne, on account of his being a papist.

EXCLUSION, in mathematics, is a method of coming at the solution of numerical problems, by previously throwing out of our consideration such numbers as are of no use in solving the question.

EXCOECARIA, a genus of the triandria order, in the diœcia class of plants; and in the natural method ranking under the 38th order, tricoccæ. The male amentum is naked; there is no calyx nor corolla; there are three styles, and a tricoccous capsule. There are two species. The agallocha, or aloes-wood, is a native of China and some of the Indian islands, and is about the same height and form as the olive-tree. Its trunk is of three colours, and contains three sorts of wood; the heart is that of tambac, or calombac, which is dearer in the Indies than even gold itself. It serves to perfume clothes and apartments; and is esteemed a sovereign cordial in fainting fits, a restorative in the palsy, and a cure for ascarides in children. It is burnt as incense in the Chinese and Indian temples; and it is also used to set the most precious jewels that are wrought in the Indies.

The aloes-wood is very highly valued; and strange fables were invented as to the origin of the tree that yields it; some pretending that it grew in Paradise, and was only conveyed to us by means of the rivers overflowing their banks and sweeping off the trees in their way; others affirming that it grew on inaccessible mountains, where it was guarded by certain wild beasts, &c. The Siamese ambassadors to the court of France in 1686, who brought a present of this wood from their emperor, gave the Europeans the first consistent account of it.

EXCOMMUNICATION, an ecclesiastical penalty or censure whereby such persons as are guilty of any notorious crime or offence, are separated from the communion of the church, and deprived of all spiritual advantages.

Excommunication among the Jews, according to Elias, a German rabbin, was distinguished into three kinds: 1. Niddui, which was a separation of but a few days. 2. Cherem, a separation attended with execration and malediction. And, 3. Shammatha, which was the last and greater excommunication. But Selden says, that niddui and shammatha are the same thing, and therefore that there were but two kinds of excommunication among the Jews, viz. the greater and the less. They made also another distinction in excommunication, into total or universal, by which a man was excommunicated with regard to all men; and partial, by which a man was excommunicated in one city, and with regard to certain persons, and not others.

It is observable, that not only the judges had the power of excommunicating, but that each particular per-

son in conversation might excommunicate another, and himself likewise; and this excommunication, if well-grounded, was of force; nay, if a man dreamed that he was excommunicated by himself or by another, he was considered as an excommunicated person, because this dream was supposed to be sent from God.

As to the effects of the Jewish excommunication, the lesser excluded the excommunicated person from the society of men; that is, he was not to come nearer them than four cubits, neither he, his wife, children, or domestics, according to Buxtorf. The greater absolutely sequestered the person from the conversation of others; and sometimes he was shut up in a small chamber or prison, where he lived alone. Baronius and Beza pretend, that the greater excommunication excluded men from the use of sacred things. Selden, on the contrary, affirms, that they were allowed to be present in the temple, and partake of the public worship. Buxtorf, who is of the same opinion, adds, that whereas others came into the temple at the right hand, and went out at the left, the excommunicated were obliged both to go in and out at the left.

Excommunication among the modern Jews, is attended with the most terrible consequences. The excommunicated person is refused all human assistance: if there is a corpse in his house, or a child to be circumcised, none must help him. He is cursed by the book of the law, by the curse of Joshua against Jericho, by that of Elisha against the children, by heaven and earth, and God is besought that a wirldwind may dash him to pieces. He is pelted with stones if he appears in the streets; and if he obtains absolution, it is upon the most mortifying conditions; for he is publicly tied to a post and whipped, after which he lays himself down at the door of the synagogue, and all those who go out, pass over him. This was the very case of the famous Jew Acosta. See Bayle, in the article Acosta.

In the ancient christian church, the power of excommunication, as well as other acts of ecclesiastical discipline, was lodged in the hands of the clergy; who distinguished it into the greater and lesser. The lesser excommunication, simply called αφοριςμος, separation or suspension, consisted in excluding men from the participation of the eucharist, and the prayers of the faithful. But they were not expelled the church; for they had the privilege of being present at the reading of the scriptures, the sermons, and the prayers of the catechumens and penitents. This excommunication was inflicted for lesser crimes, such as neglecting to attend the service of the church, and misbehaviour in it.

The greater excommunication, called παντελης αφοριςμος, total separation and anathema, consisted in an absolute and entire exclusion from the church and the participation of all its rites. When any person was thus excommunicated, notice was given of it by circular letters to the most eminent churches all over the world, that they might all confirm this act of discipline, by refusing to admit the delinquent to their communion. The consequence of this latter excommunication was very terrible. The excommunicated person was avoided in civil commerce and outward conversation. No one was to receive him into his house, nor eat at the same table with him; and when dead, he was denied the solemn rites of burial. It has been a question, whether the ancient church used to add execration to her censures. Grotius thinks this was done, though very seldom, as in the case of Julian the apostate, for whose destruction the ancient christians absolutely prayed to God. St. Chrysostom was utterly against this practice, affirming that we ought not to pray against the sinner, but against his opinions or actions.

The Romish pontifical takes notice of three kinds of excommunication: 1. The minor, incurred by those who have any correspondence with an excommunicated person. 2. The major, which falls upon those who disobey the commands of the holy see, or refuse to submit to certain points of discipline; in consequence of which they are excluded from the church militant and triumphant, and delivered over to the devil and his angels. 3. Anathema, which is properly that pronounced by the pope against heretical princes and countries. In former ages, these papal fulminations were most terrible things; but at present, they are formidable to none but a few petty states of Italy.

Excommunication, in the Greek church, cuts the offender off from all communion with the 318 fathers of the first council of Nice, and with the saints; consigns him over to the devil and the traitor Judas; and condemns his body to remain after death as hard as a flint, or a piece of steel, unless he humbles himself and makes atonement for his sins by a sincere repentance. The former abounds with dreadful imprecations; and the Greeks assert, that if a person dies excommunicated, the devil enters into the lifeless corpse; and, therefore, in order to prevent it, the relations of the deceased cut his body in pieces, and boil them in wine. It is a custom for the patriarch of Jerusalem annually to excommunicate the pope and the church of Rome; on which occasion, together with a great deal of idle ceremony, he drives a nail into the ground with a hammer, as a mark of malediction.

Excommunication, among the pagans, excluded the person from the sacrifices and the temples, and delivered him over to the Furies, which was called execrare, and Diris devovere. When Marcus Crassus set out on his expedition against the Parthians, Atteius, tribune of the people, not being able to prevent him, ran to the gate of the city through which the general was to pass, and setting a chaffing-dish in the middle of the way with fire in it, when Crassus drew near, he threw some perfumes into the chaffing-dish, and pronounced curses against Crassus with great exclamation, and thus excommunicated him.

Excommunication, in the church of England, is the highest ecclesiastical censure which can be pronounced by a spiritual judge against a christian; for thereby he is excluded from the body of the church, and disabled to bring any action, or sue any person in the common law courts. Co. Lit. 133.

The sentence of excommunication was instituted originally for preserving the purity of the church; and it seems agreed, that wherever the spiritual court has jurisdiction in any cause, and the party refuses to appear to their citation, or after sentence, being admonished to obey their de ree, that he may be excommunicated. 1 Rol. Abr. 883.

A person excommunicated is disabled to be a witness

in any cause: he cannot be attorney or procurator for another; he is to be turned out of the church by the church-wardens, and not to be allowed christian burial. Gibs. Cod. 135.

The sentence of excommunication can only be pronounced by the bishop, or other person in holy orders, being a master of arts at least; also the priest's name pronouncing such sentence, is to be expressed in the instrument issuing under seal out of the court. Gibs. Cod. 1095.

EXCOMMUNICATO CAPIENDO, a writ directed to the sheriff, for apprehending him who stands obstinately excommunicated, forty days; for such an one not seeking absolution, has, or may have, his contempt certified into the chancery; whence issues this writ, for imprisoning him without bail or mainprize until he conforms. 5 Eliz. c. 23.

EXCOMMUNICATO DELIBERANDO, a writ to the sheriff, for the delivery of an excommunicated person out of prison, upon certificate of the ordinary, of his conformity to the jurisdiction ecclesiastical. F. N. B. 63.

EXCOMMUNICATO RECIPIENDO, a writ whereby persons excommunicated, being for their obstinacy committed to prison, and unlawfully delivered thence, before they have given caution to obey the authority of the church, are commanded to be sought for and imprisoned again.

EXCORIATION, in medicine and surgery, the galling or rubbing off of the cuticle.

EXCRESCENCE, in surgery, denotes every preternatural tumour which arises upon the skin, either in the form of a wart or tubercle. If they are born with a person, as they frequently are, they are called navi materni, or marks from the mother; but if the tumour is large, so as to depend from the skin like a fleshy mass, it is then called a sarcoma. See SURGERY.

EXCRETION, or SECRETION, in medicine, a separation of some fluid, mixed with the blood, by means of the glands. See PHYSIOLOGY.

EXCRETORY, in anatomy, a term applied to certain little ducts or vessels, destined for the reception of a fluid, secreted in certain glandules, and other viscera, for the excretion of it in the appropriated places. See ANATOMY.

EXECUTION is a judicial writ, grounded on the judgment of the court whence it issues; and is supposed to be granted by the court at the request of the party at whose suit it is issued, to give him satisfaction on the judgment which he has obtained: and therefore an execution cannot be sued out in one court, upon a judgment obtained in another. Impey, K. B.

Executions in actions where money is recovered, as a debt or damages, are of five sorts: 1. against the body of the defendant; 2. against his goods or chattels; 3. against his goods and the profits of his lands; 4. against the goods and the possession of his land; 5. against all three, his body, lands, and goods. 3 Black, 414. See CAPIAS AD SATISFACIENDUM, FIERI FACIAS, LEVARI FACIAS, and ELEGIT.

EXECUTION *of criminals*, must be according to the judgment; and the king cannot alter a judgment from hanging to beheading, because no execution can be warranted, unless it is pursuant to the judgment. 3 Inst. 52.

Execution of criminals is the completion of human punishment; and this in all cases, as well capital as otherwise, must be performed by the legal officer, the sheriff or his deputy. 4 Black. 405.

EXECUTIONE FACIENDA IN WITHERNAMIUM, a writ that lies for taking his cattle who formerly had conveyed out of the county the cattle of another: so that the bailiff, having authority from the sheriff to replevy the cattle so conveyed away, could not execute his charge.

EXECUTIONE JUDICII, a writ which lies where judgment is given in any court of record, and the sheriff or bailiff neglecting to do execution of the judgment, the party shall then have this writ directed to the said sheriff or bailiff; and if they shall not do execution, he shall have an alias, and pluries. And if upon this writ execution is not done, or some reasonable cause returned why it is delayed, the judges of the court may amerce them.

EXECUTOR, is a person appointed by the testator, to carry into execution his will and testament after his decease. The regular mode of appointing an executor, is by naming him expressly in the will; but any words indicating an intention of the testator to appoint an executor will be deemed a sufficient appointment.

Any person capable of making a will, is also capable of being an executor: but in some cases, persons who are incapable of making a will, may nevertheless act as executors, as infants, or married women; to obviate, however, inconveniences which have occurred respecting the former, it is enacted by stat. 38 Geo. III. c. 89, that where an infant is sole executor, administration, with the will annexed, shall be granted to the guardian of such infant, or such other person as the spiritual court shall think fit, until such infant shall have attained the age of twenty-one; when, and not before, probate of the will shall be granted him.

An executor derives his authority from the will and not from the probate, and is therefore authorized to do many acts in execution of the will, even before it is proved, such as releasing, paying, or receiving of debts, assenting to licences, &c. but he cannot proceed until he has obtained probate.

If an executor dies before probate, administration must be taken out with the will annexed; but if an executor dies, his executor will be executor to the first testator, and no fresh probate will be needed. It will be sufficient if one only of the executors prove the will; but if all refuse to prove, they cannot afterwards administer, or in any respect act as executors.

If an executor becomes a bankrupt, the court of chancery will appoint a receiver of the testator's effects, as it will also upon the application of a creditor, if he appears to be wasting the assets.

If an executor once administers, he cannot afterwards renounce; and the ordinary may in such case issue process to compel him to prove the will. 1 Mod. 213.

If an executor refuses to take upon him the execution of the will, he shall lose the legacy therein contained.

If a creditor constitutes his debtor his executor, this is at law a discharge of the debt, whether the executor acts or not, provided however there be assets sufficient to discharge the debts of the testator.

The first duty of an executor or administrator is to bury the deceased in a suitable manner; and if the execu-

tor exceeds what is necessary in this respect, it will be a waste of the substance of the testator.

The next thing to be done by the executor is to prove the will, which may be done either in the common form, by taking the oath to make due distribution, &c. or in a more solemn mode, by witnesses to its execution.

By stat. 37 Geo. III. c. 9. s. 10, every person who shall administer the personal estate of any person dying without proving the will of the deceased, or taking out letters of administration within six calendar months after such person's decease, shall forfeit 50*l*.

Upon proving the will, the original is to be deposited in the registry of the ordinary, by whom a copy is made upon parchment under his seal, and delivered to the executor or administrator, together with a certificate of its having been proved before him, and this is termed the probate.

If all the goods of the deceased lie within the same jurisdiction, the probate is to be made before the ordinary or bishop of the diocese, where the deceased resided; but if he had goods and chattels to the value of 5*l*. in two distinct dioceses or jurisdictions, the will may be proved before the metropolitan or archbishop of the province in which the deceased died.

An executor, by virtue of the will of the testator, has an interest in all the goods and chattels, whether real or personal, in possession or in action of the deceased; and all goods and effects coming to his hands will be the assets to make him chargeable to creditors and legatees.

An executor or administrator stands personally responsible for the due discharge of his duty; if, therefore, the property of the deceased is lost, or through his wilful negligence becomes otherwise irrecoverable, he will be liable to make it good; and also where he retains money in his hands longer than is necessary, he will be chargeable not only with interest but costs, if any have been incurred.

But one executor shall not be answerable for money received, or detriment occasioned by the other, unless it has been by some act done between them jointly.

An executor or administrator has the same remedy for recovering debts and duties, as the deceased would have had if living.

Neither an executor nor administrator can maintain any action, for a personal injury done to the deceased, when such injury is of such a nature for which damages may be received; in actions however, which have their origin in breach of promise, although the suit may abate by the death of the party, yet it may be revived either by his executors or administrators, who may also sue for rent in arrear, and due to the deceased in his life time.

By the custom of merchants, an executor or administrator may indorse over a bill of exchange or promissory note.

An executor or administrator may also, on the death of a lessee for years, assign over the lease, and shall not be answerable for rent after such assignment; nor shall he be liable for rent due after the lessee's death, from premises which in his life-time he had assigned to another.

An executor or administrator is bound only by such covenants in a lease as are said to run with the land.

The executor or administrator, previous to the distribution of the property of the deceased, must take an inventory of all his goods and chattels, which must, if required, be delivered to the ordinary upon oath.

He must then collect, with all possible convenience, all the goods and effects contained in such an inventory; and whatever is so recovered that is of a saleable nature, and can be converted into money, is termed assets, and makes him responsible to such amount to the creditors, legatees, and kindred of the deceased.

The executor or administrator having collected in the property, is to proceed to discharge the debts of the deceased, which he must do according to the following priorites, otherwise he will be personally responsible.

1. Funeral expenses, charges of proving the will, and other expenditures incurred by the execution of his trust.

2. Debts due to the king on record, or by speciality.

3. Debts by particular statutes, as by 30 C. II. c. 23. Forfeitures for not burying in woollen, money due for poor-rates, and money due to the post-office.

4. Debts of record, as judgments, statutes, recognizances, and those recognized by a decree of a court of equity; and debts due on mortgage. 3 Peere Wms. 401.

5. Debts on special contracts, as bonds or other instruments under seal, and also rent in arrear.

6. Debts on simple contract, viz. such as debts arising by mere verbal promise, or by writing, not under seal, as notes of hand, servants' wages, &c.

The executor is bound at his peril to take notice of debts on record, but not of other special contracts, unless he receives notice.

If no suit is actually commenced against an executor or administrator, he may pay one creditor in equal degree the whole debt, though there should be insufficient remaining to pay the rest; and even after the commencement of a suit, he may by confessing judgment to other creditors of the same degree, give them a preference.

Executors and administrators are also allowed, amongst debts of equal degree, to pay themselves first: but they are not allowed to retain their own debt, to the prejudice of others in a higher degree; neither shall they be permitted to retain their own debts, in preferance to that of their co-executor or co-administrator of equal degree, but both shall be charged in equal proportion.

A mortgage made by the testator must be discharged by the representative out of the personal estate, if there is sufficient to pay the rest of the creditors and legatees. Where such mortgage, however, was not incurred by the deceased, it is not payable out of the personal estate. See LEGACIES, and ASSETS.

EXECUTOR *de son tort*, or an executor of his own wrong, a person that takes upon him the office of an executor by intrusion, without being so constituted by the testator, or appointed by the ordinary to administer. Such a person is chargeable to the rightful executor, as also to all the testator's creditors and legatees, so far as the goods amount to which he wrongfully possessed.

EXECUTORY ESTATE. Estates executory, are when they pass presently to the person to whom conveyed, without any after-act, 2 Inst. 513; and leases for years, rents, annuities, conditions, &c. are called inheritances executory. Id. 293.

EXECUTORY *devise*, is defined a future interest, which

cannot vest at the death of a testator, but depends upon some contingency which must happen before it can vest. Abr. Eq. 186.

An executory devise differs from a remainder, in three very material points: 1. That it needs not any particular estate to support it. 2. That by it a fee-simple, or other less estate, may be limited after a fee-simple. 3. That hereby a remainder may be limited of a chattel interest, after a particular estate for life created in the same. 2 Black. 172.

Executory devises of terms for years.—If a farmer devises his term to A for life, the remainder to another, though A have the whole estate (for that is in him during his life) and so no remainder can be limited over, at common law, yet it is good by way of executory devise. 1 Rol. Abr. 610.

EXEDRÆ, in antiquity, a general name for such buildings as were distinct from the main body of the churches, and yet within the limits of the church taken in its largest sense. Among the exedræ the chief was the baptistery. Exedræ were also halls of little academies with several seats, upon which philosophers, rhetoricians, &c. sat when they met for conversation or disputation. Vitruvius speaks of them as places very open and exposed to the sun.

EXEGESIS, a discourse by way of explanation or comment upon any subject. In the Scotch universities there is an exercise among the students in divinity called an exegesis, in which a question is stated by the respondent, who is then opposed by two or three other students in their turns; during which time the professor moderates, and solves the difficulties which the respondent cannot overcome.

EXEMPLIFICATION *of letters patent*, a transcript or duplicate of them, made from the enrolment thereof, and sealed with the great seal. These exemplifications are by statute equally effectual, and may be pleaded as well as the originals. One may exemplify a patent under the great seal in chancery; also any record or judgment in any of the courts at Westminster, under the seal of each court; which exemplifications may be given in evidence to a jury. It is held, that nothing but matter of record ought to be exemplified.

EXEMPTION, in law, a privilege to be free from some service or appearance: thus; barons and peers of the realm are, on account of their dignity, exempted from being sworn upon inquests; and knights, clergymen, and others, from appearing at the sheriff's tourn. Persons of seventy years of age, apothecaries, &c. are also by law exempted from serving on juries; and justices of the peace, attorneys, &c. from parish-offices.

Exemption, in the church of Rome, a privilege granted by the pope to the clergy, and sometimes to the laity, to exempt or free them from the jurisdiction of their respective ordinaries. Thus monasteries, and even private priests, for a small charge formerly procured exemptions from the jurisdiction of their bishops. In this, however, the council of Trent made a small reformation, by abolishing the exemption of particular priests, and monks not living in cloisters, and that of chapters in criminal matters.

EXERCISE, among physicians, such an agitation of the body as produces salutary effects in the animal œconomy. See Medicine.

Exercise, in military affairs, is the practice of all those motions and actions, together with the whole management of arms, which a soldier is to be perfect in, to render him fit for service, and make him understand how to attack and defend. Exercise is the first part of the military art; and the more it is considered, the more essential it will appear. It disengages the human frame from the stiff rusticity of simple nature, and forms men and horses to all the evolutions of war. The honour, merit, appearance, strength, and success of a corps, depend wholly upon the attention which has been paid to the drill and exercise of it, according to prescribed rules and regulations; while on the other hand we see the greatest armies, for want of being exercised, instantly disordered, and that disorder increasing in spite of command; the confusion oversets the art of skilful masters, and the valour of the men only serves to precipitate the defeat; for which reason it is the duty of every officer to take care that the recruits be drilled as soon as they join the corps.

The greatest advantage derived from exercise, is the expertness with which men become capable of loading and firing, and their learning an attention to act in conformity with those around them. It has always been lamented, that men have been brought on service, without being informed of the uses of the different manœuvres they have been practising; and that having no ideas of any thing but the uniformity of the parade, they instantly fall into disorder and confusion when they lose the step, or see a deviation from the straight lines they have been accustomed to at exercise. It is a pity to see so much attention confined to show, and so little given to instruct the troops in what may be of use to them on service. Though the parade is the place to form the characters of soldiers, and to teach them uniformity, yet when confined to that alone, it is too limited and mechanical for a true military genius.

The great loss which the British troops sustained in Germany, America, and the West Indies, during a former war, from sickness, and not from the enemy, was chiefly owing to a neglect of exercise. An army whose numbers vanish after the first four months of a campaign, may be very ready to give battle in their existing period; but the fact is, that although fighting is one part of a soldier's business, yet bearing fatigue, and being in health, is another, and at least as essential as the first. A campaign may pass without a battle, but no part of a campaign can be gone through without fatigue, without marches, without an exposure to bad weather; all of which have exercise for their foundation; and if soldiers are not trained and inured to these casualties, but sink under them, they become inadequate to bodily fatigue, and eventually turn out a burthen to their country.

It is not from numbers, or from inconsiderate valour, that we are to expect victory; in battle it commonly follows capacity, and a knowledge of arms. We do not see that the Romans made use of any other means to conquer the world, than a continual practice of military exercises, an exact discipline in their camps, and a constant attention to cultivate the art of war. Hence, both ancients and moderns agree, that there is no other way to form

good soldiers but by exercise and discipline; and it is by a continual practice and attention to this, that the Prussians arrived at that point of perfection which has been so much admired in their evolutions, and manual exercise.

Formerly in the British service every commander in chief, or officer commanding a corps, adopted or invented such manœuvres as he judged proper, excepting in the instance of a few regulations for review; neither the manual exercise, nor quick and slow marching, were precisely defined by authority. In consequence, when regiments from different parts of the kingdom were brigaded, they were unable to act in line till the general officer commanding had established some temporary system to be observed by all under his command.

These inconveniences were at length obviated by the rules and regulations compiled by general Dundas on the system of the Prussian discipline, as established by Frederic the Great.

By his majesty's orders issued in 1792, this system is directed to be "strictly followed and adhered to, without any deviation whatsoever. And such orders before given, as are found to interfere with, or counteract their effect and operation, are to be considered as cancelled and annulled."

Exercise *of the infantry*, includes the use of the firelock and practice of the manœuvres for regiments of foot, according to the regulations issued by authority.

When a regiment of foot is drawn up, or paraded for exercise, the men are placed two, and sometimes three deep, which latter is the natural formation of a battalion. The grenadiers are on the right, and the light infantry on the left. In order to have the manual exercise well performed, it is in a particular manner requisite, that the ranks and files be even, well dressed, and the file-leaders well covered; this must be very strictly attended to both by the major and his adjutant; all officers also, on service in general, where men are drawn up under arms, or without, must be careful that the ranks and files are exactly even, and the soldiers must learn to dress themselves at once, without the necessity of being directed to do it. The beauty of all exercise and marching consists in seeing a soldier carry his arms well, keep his firelock steady and even in the hollow of his shoulder, the right hand hanging down, and the whole body without constraint. The musquets when shouldered, should be exactly dressed in rank and file; the men must keep their bodies upright, and in full front, not having one shoulder too forward, or the other too backward. The distances between the files must be equal, and not greater than from arm to arm, which gives the requisite room for the motions. The ranks are to be two paces distant from each other. Every motion must be done with life, and all facings, wheelings, and marchings, performed with the greatest exactness. Hence a regiment should never be under arms longer than two hours.

Exercise *of the cavalry*, is of two sorts, on horseback and on foot. The squadrons for exercise are sometimes drawn up three deep, though frequently two deep; the tallest men and horses in the front, and so on. When a regiment is formed in squadrons, the distance of 24 feet, as a common interval, is always to be left between the ranks, and the files must keep boot-top to boot-top. The officers commanding squadrons must, above all things, be careful to form with great celerity, and during the whole time of exercise to preserve their several distances. In all wheelings, the flank which wheels must come about in full gallop. The men must keep a steady seat upon their horses, and have their stirrups at a fit length.

Exercise *of the artillery*, is the method of teaching the regiments of artillery the use and practice of all the various machines of war, viz.

Exercise *of the light field-pieces* teaches the men to load, ram, and sponge the guns well; to elevate them according to the distance, by quadrant and screw; to judge of distances and elevations without the quadrant; how to use the portfire, match, and tubes for quick firing; how to fix the drag-ropes, and use them in advancing, retreating, and wheeling with the field-pieces; how to fix and unfix the trail of the carriage on the limbers, and how to fix and unfix the boxes for grape-shot on the carriages of each peice.

Exercise *of the garrison and battering artillery*, is to teach the men how to load, ram, and sponge; how to handle the hand-spikes in elevating and depressing the metal to given distances, and for ricochet; how to adjust the coins, and work the gun to its proper place; and how to point and fire with exactness, &c.

Exercise *for the mortar*, is of two different sorts, viz. with powder and shells unloaded, and with powder and shells loaded; each of which is to teach the men their duty, and to make them handy in using the implements for loading, pointing, traversing, and firing, &c.

Exercise *of the howitzer*, differs but little from the mortar, except that it is liable to various elevations; whereas that of the mortar is fixed to an angle of 45°; but the men should be taught the method of ricochet-firing, and how to practise with grape-shot; each method requiring a particular degree of elevation.

Exercises are also understood of what young gentlemen or cadets learn in the military academies and riding-schools; such as fencing, dancing, riding, the manual exercise, &c. The late establishment at High Wycomb is calculated to render young officers perfectly competent to all the duties of military service, provided they have been previously instructed in the first rudiments. Officers are there taught and exercised in the higher branches of tactics and manœuvres.

EX GRAVI QUERELA, in law, is a writ that lies for the person to whom any lands or tenements in fee are devised by will, and the heir of the devisor enters thereon, and detains them from the devisee. Also where a person devises such lands to another in tail with the remainder over in fee; here if the tenant in tail enters, and is seized by force of the intail, and afterwards he dies without issue, the person in remainder, or reversion, may bring this writ to execute the devise.

EXHALATION, a general term for all effluvia or steams, whether moist or dry, raised from the surface of the earth, in form of vapour. In the strict sense of the word, it applies to dry particles in opposition to Evaporation, which see.

Some indeed distinguish exhalations from vapours; expressing by the former all steams emitted from solid bodies, as earth, fire, sulphur, salts, minerals, &c. and by the latter, the steams raised from water and other

fluids. Exhalations, therefore, according to them, are dry, subtile corpuscles, or effluvia, which are loosened and freed from hard earthy bodies, either by the heat of the sun, the agitation of the air, or the like causes; and being blended in the atmosphere with the moist vapours, help to constitute or form clouds and meteors. See METEOROLOGY.

EXHAUSTIONS, or *the method of Exhaustions*, a method of demonstration founded upon a kind of exhausting a quantity, by continually taking away certain parts of it.

The method of exhaustions was of frequent use among the ancient mathematicians, as Euclid, Archimedes, &c. It is founded on what Euclid says in the 10th book of his Elements, viz. that those quantities are equal whose difference is less than any assignable quantity. Or thus: two quantities, A and B, are equal, when, if to or from one of them, as A, any other quantity, as d, be subtracted, however small it be, then the sum or difference is respectively greater or less than the other quantity B, viz. d being an indefinitely small quantity,

if $A + d$ be greater than B,
and $A - d$ less than B,
then is A equal to B.

This principle is used in the 1st prop. of the 10th book, which imports, that if from the greater of two quantities be taken more than its half, and from the remainder more than its half, and so on, there will at length remain a quantity less than either of those proposed. On this foundation it is demonstrated, that if a regular polygon of an infinite number of sides be inscribed in a circle, or circumscribed about it; then the space, which is the difference between the circle and the polygon, will by degrees be quite exhausted, and the circle become ultimately equal to the polygon. And in this way it is that Archimedes demonstrates that a circle is equal to a right-angled triangle, whose two sides about the right angle are equal, the one to the semidiameter, and the other to the perimeter of the circle.

Upon the method of exhaustions depends the method of indivisibles introduced by Cavalerius, which is but a shorter way of expressing the method of exhaustions: as also Wallis's Arithmetic of Infinites, which is a farther improvement of the method of indivisibles; and hence also the methods of increments, differentials, fluxions and infinite series.

EXHEREDATION, in the civil law, the exclusion of a son by the father from inheriting his estate, termed among us disinheriting.

EXHIBIT, in law, is where a deed, or other writing, being produced in a chancery suit, to be proved by witnesses, the examiner or commissioner appointed after the examination of any such, certifies on the back of the deed, or writing, that the same was shown to the witness, at the time of his examination, and by him sworn to.

EXHUMATION, the digging up of a body interred in holy ground, by the authority of a judge. By the French law the exhumation of a dead body is ordered, upon proof that he was killed in a duel; and a parson may demand the exhumation of any of his parishioners, when interred out of the parish without his consent.

EXIGENT, in law, a writ which lies where the defendant in a personal action cannot be found, nor any effects of his within the county, by which he may be attached or distrained. This writ is directed to the sheriff, to proclaim and call the defendant five county-court days, one day after another, charging him to appear under the pain of outlawry. Where a person indicted of felony, &c. absents himself so long, that the writ of exigent is awarded against him, such a withdrawing will be deemed a flight in law, whereby he is liable to forfeit his goods; and though he afterwards renders himself on the exigent, and is found not guilty, it is said the forfeiture shall stand; but if the party was in prison, or beyond the seas, he, or his executors, may reverse the award of the exigent, by writ of error. Upon all exigents a proclamation shall be issued out to make proclamation in the county where the defendant dwells, for him to yield himself, &c.

EXIGENTERS, four officers in the court of common-pleas, who make all exigents and proclamations, in all actions where process of outlawry lies. Writs of supersedeas, as well as the prothonotaries upon exigents, were likewise drawn up in their office.

EXILIUM, in law, signifies a spoiling, but seems to be restrained to the injury done to tenants by altering their tenure, ejecting them, &c.

EXIT, in law, properly signifies issue or offspring; but is also applied to issues, annual rents, and profits of lands.

EX MERO MOTU, a formula used in the king's charters and letters patent, signifying that he grants them of his own will and motion. It is intended to bar all exceptions that might be taken to the charter or patent, by alleging the king, in granting them, was abused by false suggestions.

EXOACANTHA, a genus of the class and order pentandria digynia. The involucrum is spiny. The flowers all hermaphrodite, with equal inflexions; seeds ovate, striated. There is one species, of no note.

EXOCOETUS, or the *flying-fish*, in ichthyology, a genus belonging to the order of abdominales. See Plate LV. Nat. Hist. fig. 190. The head is scaly, and it has no teeth; it has 10 radii in the branchiostege membrane; the body is whitish, and the belly is angular; the pectoral fins, the instruments of flight, are very large. When pursued by any other fish, it raises itself from the water by means of these long fins, and flies in the air to a considerable distance, till the fins dry, and then it falls down into the water. It is a fish that seems to lead a most miserable life. In its own element it is perpetually harassed by the dorados and other fish of prey. If it endeavours to avoid them by having recourse to the air, it either meets its fate from the gulls or the albatross, or is forced down again into the mouths of the inhabitants of the water, who below keep pace with its aerial excursions. This fish is caught in the Mediterranean and some other seas. It is most common between the tropics, and there its enemies are more particularly numerous. In these climates the flying-fishes spring out of the water by hundreds, to escape the rapacity of the dolphins, sharks, &c. When in the air, they have many formidable enemies to encoun-

ter within that element, viz. the pelican, eagle, diomeda, &c. and frequently throw themselves on board the ships to escape their pursuit. Their flesh is said to supply a palatable and nourishing food. There are two species.

EX OFFICIO, among lawyers, signifies the power a person has, by virtue of his office, to do certain acts without being applied to. Thus a justice of peace may ex officio at his discretion, take surety of the peace, without complaint made by any person whatsoever. There was formerly an oath ex officio, whereby a supposed offender was compelled in the ecclesiastical court to confess, accuse, or clear himself of a crime; but this law is repealed.

EXOMPHALUS, in surgery, called also omphalocele, and hernia umbilicalis, is a preternatural tumor of the abdomen at the navel from a rupture, or distention of the parts which invest that cavity. See SURGERY.

EXORCISM, among the ecclesiastical writers, the expelling devils from persons possessed, by means of conjurations and prayers.

EXORCISTS, in church history, an order of men, in the ancient church, whose employment it was to exorcise or cast out devils. See the preceding article.

EXORDIUM, in rhetoric, is the preamble or beginning, serving to prepare the audience for the rest of the discourse.

EXOTIC, an appellation denoting a thing to be the produce of foreign countries. Exotic plants of the hot climates are very numerous, and require the utmost attention of the gardener to make them thrive with us.

EXPANSION, as generally employed in science, denotes an increase of the bulk of any body by a power acting from within.

It may be laid down as a general rule, to which there is no known exception, that every addition or abstraction of caloric makes a corresponding change in the bulk of the body which has been subjected to this alteration in the quantity of its heat. In general the addition of heat increases the bulk of a body, and the abstraction of it diminishes its bulk; but this is not uniformly the case, though the exceptions are not numerous. Indeed these exceptions are not only confined to a very small number of bodies, but even in them they do not hold, except at certain particular temperatures, while at all other temperatures these bodies are increased in bulk when heated, and diminished in bulk by being cooled. We may therefore consider expansion as one of the most general effects of heat. It is certainly one of the most important, as it has furnished us with the means of measuring all the others.

Though all bodies are expanded by heat and contracted by cold, and this expansion in the same body is always proportional to some function of the quantity of caloric added or subtracted; yet the absolute expansion, or contraction, has been found to differ exceedingly in different bodies. In general, the expansion of gaseous bodies is greatest of all; that of liquids is much smaller, and that of solids the smallest of all. Thus, 100 cubic inches of atmospheric air, by being heated from the temperature of 32° to that of 212°, are increased to 137.5 cubic inches; while the same augmentation of temperature only makes 100 cubic inches of water assume the bulk of 104.5 cubic inches; and 100 cubic inches of iron, when heated from 32° to 212°, assume a bulk scarcely exceeding 100.1 cubic inches. From this example, we see that the expansion of air is more than eight times greater than that of water, and the expansion of water about 45 times greater than that of iron.

An accurate knowledge of the expansion of gaseous bodies being frequently of great importance in chemical researches, many experiments have been made to ascertain it; yet. till lately, the problem was unsolved. The results of philosophers were so various and discordant, that it was impossible to form any opinion on the subject. This was owing to the want of sufficient care in excluding water from the vessels in which the expansion of the gases was measured. The heat which was applied converted portions of this water into vapour, which, mixing with the gas, totally disguised the real changes in bulk which it had undergone. To this circumstance we are to ascribe the difference in the determinations of de Luc, general Roy, Saussure, d'Ivernois, &c. Fortunately the problem has lately engaged the attention of Mr. Dalton of Manchester, and M. Gay Lussac; and their experiments, made with the proper precautions, have solved the problem. Mr. Dalton's experiments are distinguished by a simplicity of apparatus which adds greatly to their value, as it puts it in the power of others to repeat them without difficulty. It consists merely of a glass tube, open at one end, and divided into equal parts; the gas to be examined was introduced into it after being properly dried, and the tube is filled with mercury at the open end to a given point; heat is then applied, and the dilatation is observed by the quantity of mercury which is pushed out. M. Gay Lussac's apparatus is more complicated, but equally precise; and as his experiments were made on larger bulks of air, the coincidence with those of Mr. Dalton adds considerably to the confidence which may be placed in the results.

From the experiments of these philosophers it follows, that all gaseous bodies whatever undergo the same expansion by the same addition of heat, supposing them placed in the same circumstances. It is sufficient then to ascertain the law of expansion observed by any one gaseous body, in order to know the exact rate of dilatation of them all. Now, from the experiments of Gay Lussac we learn, that air, by being heated from 32° to 212°, expands from 100 to 137.5 parts; the increase of bulk for 180° is then 37.5 parts; or, supposing the bulk at 32° to be unity, the increase is equal to 0.375 parts; this gives us 0.00208, or $\frac{1}{480}$th part, for the expansion of air for 1° of the thermometer. Mr. Dalton found, that 100 parts of air, by being heated from 55° to 212°, expanded to 132.5 parts; this gives us an expansion of 0.00207, or $\frac{1}{483}$ part, for 1°; which differs as little from the determination of Lussac as can be expected in experiments of such delicacy.

From the experiments of Mr. Dalton, it appears that the expansion of air is almost perfectly equable; that is to say, that the same increase of bulk takes place by the same addition of caloric at all different temperatures. It is true, indeed, that the rate of diminution appears to diminish as the temperature increases. Thus the expansion from 55° to 133$\frac{1}{2}$°, or for the first 77$\frac{1}{2}$ degrees, was 167 parts; while the expansion from 133$\frac{1}{2}$ to 212°, or for the next 77$\frac{1}{2}$°, was only 158 parts, or 9 parts less than

the first. But this difference, in all likelihood, is chiefly apparent; for de Luc has demonstrated that the thermometer is not an accurate measure of the increase of heat.

From the experiments of Gay Lussac, it appears that the steam of water, and the vapour of ether, undergo the same dilatation with air when the same addition is made to their temperature. We may conclude then that all elastic fluids expand equally and uniformly by heat; and that this expansion is nearly equable, though not perfectly so. The following table gives us the bulk of a given quantity of air at all temperatures from 32° to 212°.

Tem.	Bulk.	Tem.	Bulk.	Tem.	Bulk.
32°	100000	59°	105616	86°	111232
33	100208	60	105824	87	111440
34	100416	61	106032	88	111648
35	100624	62	106240	89	111856
36	100832	63	106448	90	112064
37	101040	64	106656	91	112272
38	101248	65	106864	92	112486
39	101456	66	107070	93	112688
40	101664	67	107280	94	112896
41	101872	68	107488	95	113104
42	102080	69	107696	96	113312
43	102288	70	107904	97	113520
44	102496	71	108112	98	113728
45	102764	72	108320	99	113936
46	102912	73	108528	100	114144
47	103120	74	108736	110	116224
48	103328	75	108944	120	118304
49	103536	76	109152	130	120384
50	103744	77	109360	140	122464
51	103952	78	109568	150	144544
52	104160	79	109776	160	126624
53	104268	80	109984	170	128704
54	104576	81	110192	180	130784
55	104784	82	110400	190	132864
56	104992	83	110608	200	134944
57	105220	84	110816	210	137024
58	105408	85	111024	212	137440

The expansion of liquid bodies differs from that of the elastic fluids, not only in quantity, but in the want of uniformity with which they expand when equal additions are made to the temperature of each. This difference seems to depend upon the fixity or volatility of the component parts of the liquid bodies; for in general those liquids expand most by a given addition of heat, whose boiling temperatures are lowest, or which contain in them an ingredient which readily assumes the gaseous form. Thus mercury expands less when heated to a given temperature than water, which boils at a heat much inferior to mercury; and alcohol is much more expanded than water, because its boiling temperature is lower. In like manner nitric acid is much more expanded than sulphuric acid; not only because its boiling point is lower, but because a portion of it has a tendency to assume the form of an elastic fluid. We may consider it therefore as a pretty general fact, that the higher the temperature necessary to cause a liquid to boil, the smaller is the expansion which is produced by the addition of a degree of heat; or, in other words, the expansibility of liquids is nearly inversely as their boiling temperature.

Another circumstance respecting the expansion of liquids deserves particular attention. The expansibility of every one seems to increase with the temperature; or, in other words, the nearer a liquid is to the temperature at which it boils, the greater is the expansion produced by the addition of a degree of caloric; and, on the other hand, the farther it is from the boiling temperature, the smaller is the increase of bulk produced by the addition of a degree of caloric. Hence it happens, that the expansion of those liquids approaches nearest to equability whose boiling temperatures are highest; or, to speak more precisely, the ratio of the expansibility increases the more slowly, the higher the boiling temperature.

These observations are sufficient to show, that the expansion of liquids is altogether unconnected with their density. It depends upon the quantity of heat necessary to cause them to boil, and to convert them into elastic fluids. But we are altogether ignorant at present of the reason why different liquids require different temperatures to produce this change.

The following table will give the reader a precise notion of the rate of expansion of those liquids which have been hitherto examined by chemical philosophers.

Temp.	Mercury.	Linseed oil.	Sulphuric acid.	Nitric acid.	Water.	Oil of turpentine.	Alcohol.
30°	100000	100000	—	—	—	—	100000
40	100081	—	99752	99514	—	—	100539
50	100183	—	100000	100000	100023	100000	101105
60	100304	—	100279	100486	100091	100460	101688
70	100406	—	100558	100990	100197	100993	102281
80	100548	—	100806	101530	100332	101471	102890
90	100610	—	101054	102088	100694	101931	103517
100	100712	102760	101317	102620	100908	102446	104162
110	100813	—	101540	103196	—	102943	—
120	100915	—	101834	103776	101404	103421	—
130	101017	—	102097	104352	—	103954	—
140	101119	—	102320	105132	—	104573	—
150	101220	—	102614	—	102017	—	—
160	101322	—	102893	—	—	—	—
170	101424	—	103116	—	—	—	—
180	101526	—	103339	—	—	—	—
190	101628	—	103587	—	103617	—	—
200	101730	—	103911	—	—	—	—
212	101835	107250	—	—	104577	—	—

The expansion of solid bodies is so small, that a micrometer is necessary to detect the increase of bulk. As far as is known, the expansion is equable, at least the deviation from perfect equality is insensible. The following table exhibits the expansion of most of the solids which have been hitherto examined. Most of the experiments were made by Smeaton.

Temp.	Platinum.	Antimony.	Steel.	Iron.	Cast-Iron.	Bismuth.
32°	120000	120000	120000	120000	120000	120000
212	120104	120130	120147	120151		120167
White-heat			123428	121500	122571	

Temp.	Copper.	Cast Brass.	Brass wire.	Tin.	Lead.	Zinc.
32°	120000	120000	120000	120000	120000	120000
212	120204	120225	120232	120298	120344	120355

Temp.	Hammered zinc.	Zinc 8. Tin 1.	Lead 2. Tin 1.	Brass 2. Zinc 1.	Pewter.	Copper 3. Tin 1.
32°	120000	120000	120000	120000	120000	120000
212	120373	120323	120301	120247	120274	120218

The expansion of glass is a point of great importance, as it influences the result of most experiments on temperature. It has been examined with much precision by M. de Luc. The rate of its expansion, as settled by that philosopher, may be seen in the following table:

Temp.	Bulk.	Temp.	Bulk.	Temp.	Bulk.
32°	100000	100°	100023	167°	100056
50	100006	120	100033	190	100069
70	100014	150	100044	212	100083

From this table it appears, that when glass is heated one degree, it undergoes an expansion which amounts nearly to $\frac{1}{200000}$ of the whole bulk.

On the supposition that metals expand equably, the expansion of a mass of metal, by being heated a given number of degrees, is as follows: Let a = the expansion of the mass in length for 1°, which must be found by experiment; b = the number of degrees whose expansion is required; s = the solid contents of the metallic mass; x = the expansion sought; then $x = 3\,b\,a\,s$.

The property which bodies possess of expanding when heat is applied to them, has furnished us with an instrument for measuring the relative temperature of bodies. See THERMOMETER.

Having considered the phenomena and laws of expansion as far as they are understood, it will be proper to state the exceptions to this general effect of heat, or the cases in which expansion is produced not by an increase, but by a diminution of temperature. These exceptions may be divided into two classes. The first class comprehends certain liquid bodies which have a maximum of density corresponding with a certain temperature; and which, if they are heated above that temperature, or cooled down below it, undergo in both cases an expansion or increase of bulk. The second class comprehends certain liquids which suddenly become solid when cooled down to a certain temperature; and this solidification is accompanied by an increase of bulk.

Water furnishes us with the most remarkable example of the first class of bodies. Its maximum of density corresponds with 42.5° of Fahrenheit's thermometer, as has been lately ascertained by Mr. Dalton. If it is cooled down below 42.5°, it undergoes an expansion for every degree of temperature which it loses; and 32° the expansion amounts, according to Mr. Dalton, to $\frac{1}{160}$ of the whole expansion which water undergoes when heated from 42.5° to 212°. With this more recent experiments coincide very nearly; for by cooling 100000 parts in bulk of water from 42.5° to 32°, they were converted to 100031 parts. We are indebted to the ingenuity of Mr. Dalton for the discovery of a very unexpected fact, that the expansion of water is the same for any number of degrees above or below the maximum of density. Thus if we heat water ten degrees above 42.5°, it occupies precisely the same bulk as it does when cooled down ten degrees below 42.5°. Therefore the density of water at 32° and at 53° is precisely the same. Mr. Dalton succeeded in cooling water down to the temperature of 5° without freezing, or 37.5° below the maximum point of density; and during the whole of that range, its bulk precisely corresponds with the bulk of water the same number of degrees above 42.5°. Thus the bulk of water at 5° is the same as the bulk of water at 80°. The scale of expansion, therefore, which has been given for the expansion of water when heated, answers also for its expansion when cooled, provided the table begin at 42.5°, as is done in the table of the expansion of water. From this table it appears that the expansion of water, the original bulk being 10000, may be expressed pretty nearly by the following numbers:

Temp.		Expan.
82.5°	.	6^2
102.5°	.	8^2
122.5°	.	10^2
142.5°	.	12^2
162.5°	.	14^2

The greatest deviation from these numbers is towards the beginning of the scale, when, owing to the smallness of the expansion, it is difficult to measure it with precision. It leads us to this remarkable conclusion, that the squares of the natural numbers beginning at 6 indicate the increase of bulk which 10000 parts of water experience for every ten degrees they are heated

happen; the probability that a life of 30 will not live 10 years, is therefore $\frac{750}{4335}$, consequently the odds of living to dying in this period, are nearly 5 to 1. The probability that a person of 21 shall attain to 51, appears by the table to be $\frac{2530}{5060}$, or an even chance.

TABLE II.

Showing the Expectation of Human Life at every Age, according to the Probabilities in the preceding Table.

Age.	Expectation.	Age.	Expectation.	Age.	Expectation.
0	25,18	33	26,72	66	10,42
1	32 74	34	26,20	67	9,96
2	37,79	35	25,68	68	9,50
3	39 55	36	25,16	69	9,05
4	40,58	37	24,64	70	8,60
5	40,84	38	24,12	71	8,17
6	41,07	39	23,60	72	7,74
7	41,03	40	23,08	73	7,33
8	40,79	41	22,56	74	6,92
9	40,36	42	22,04	75	6,54
10	39,78	43	21,54	76	6.18
11	39,14	44	21,03	77	5,83
12	38,49	45	20,52	78	5,48
13	37,83	46	20,02	79	5,11
14	37,17	47	19,51	80	4,75
15	36,51	48	19,00	81	4,41
16	35.85	49	18,49	82	4,09
17	35,20	50	17,99	83	3,80
18	34,58	51	17,50	84	3,58
19	33.99	52	17,02	85	3,37
20	33,43	53	16,54	86	3,19
21	32,90	54	16,06	87	3,01
22	32,39	55	15,58	88	2,86
23	31,88	56	15,10	89	2,65
24	31,36	57	14,63	90	2,41
25	30,85	58	14,15	91	2,09
26	30,33	59	13,68	92	1,75
27	29.82	60	12,21	93	1,37
28	29,30	61	12,75	94	1,05
29	28,79	62	12,28	95	0,75
30	28,27	63	11,81	96	0,50
31	27,76	64	11,35		
32	27,24	65	10,88		

These tables are, for general use, the best that have been formed; but it is well known, that the duration of human life is much influenced by different situations; that it is greater in mountainous countries than in marshy districts; and that the country in general is much more favourable to the continuance of life than large towns. In proof of the latter assertion Dr. Price has observed, that in London the greater part of the natives die under three years of age, while in the country the greater part live to marry. The observations of Mr. Muret on the state of population in the Pays de Vaud, a district of the province of Bern in Switzerland, also confirm this remark, by showing that the greater part of the inhabitants of that province live many years beyound maturity. A comparison of the expectations of life will exhibit this difference in a striking point of view.

	London.	Vienna.	Berlin	Norwich.	Brandenberg.	Sweden	Holy Cross.
At Birth	18	16½	18	23¼	30¾	34½	34
Age 10	35	37	37¼	40¼	42¼	45	46
20	29	31½	30¼	34½	34½	38	38¾
30	23½	25½	25¼	29	28¾	31¼	32¾
40	19½	20½	21	23¼	22¾	24½	26½
50	16	16	16½	17½	16½	18½	20½
60	12½	11¾	12½	12¼	11¼	12¾	14¾
70	8	8¼	8¾	8¼	7½	7¾	10
80	5	5½	6	5¼	5	4¼	5¾

Ages at which 1000 Inhabitants die, in several principal Towns and Districts.

	Stockholm.	Vienna.	Berlin.	London 1728 to 1737.	London 1771 to 1780.	Norwich.	Northampton.	Parish in Brandenberg	Sweden.	Vaud in Switzerland.
Under 10	653	673	519	590	593	560	513	423	388	347
10 to 20	39	40	26	50	46	46	47	50	42	43
20 to 30	56	40	80	59	56	53	64	41	61	47
30 to 40	64	48	86	72	66	52	64	54	60	57
40 to 50	61	52	73	70	72	57	67	58	74	75
50 to 60	50	52	80	57	61	65	70	92	92	117
60 to 70	41	48	63	48	51	74	69	116	118	146
70 to 80	29	32	50	31	38	62	66	122	119	122
80 and upwards	7	15	23	23	17	31	40	41	56	46

Proportion of Inhabitants dying annually.

In London - - - -	1 in 20¾
Edinburgh - - -	1 in 20⅔
Dublin - - - -	1 in 22
Stockholm - - - -	1 in 19
Vienna - - - -	1 in 19½
Rome - - - -	1 in 21½
Amsterdam - - -	1 in 24
Norwich - - - -	1 in 24½

Northampton - - -	1 in $26\frac{2}{5}$
Liverpool - - - -	1 in 27
Manchester - - -	1 in 28
Savannah in Georgia - -	1 in $31\frac{7}{10}$
Wirtemburgh - - -	1 in 32
Sweden - - - -	1 in 35
Kingdom of Naples - -	1 in $37\frac{1}{3}$
Parish in Brandenberg -	1 in 45
Pays de Vaud - - -	1 in 45
Philadelphia - - -	1 in 45
Ackworth in Yorkshire -	1 in 47
Salem in Massachusetts -	1 in 47
Island of Madeira - -	1 in 50
Corfe-castle, Dorset - -	1 in $56\frac{1}{3}$

These comparisons strongly show the baleful influence of great cities, in shortening human life. The irregular modes of life, the luxuries, debaucheries, and pernicious customs, which prevail much more in towns than in the country; and the foulness of the air, which is rendered in a great degree unfit for respiration; are undoubtedly the causes which produce this fatal effect.

EXPECTORANTS. See Pharmacy.

EXPECTORATION, the act of evacuating or bringing up phlegm, or other matters, out of the trachea and lungs, by coughing, &c.

EXPENDITORS, the persons who disburse or expend the money collected by the tax for repairs of sewers, after the same is paid into their hands by the collectors, as ordered by the commissioners, and for which they are to render accounts when required.

EXPENSIS MILITUM LEVANDIS, a writ anciently directed to the sheriff for levying the allowance for knights of the shire; and expensis militum non levandis, was a writ to hinder the sheriff from levying such allowance upon lands that held in ancient demesne.

EXPERIMENTAL PHILOSOPHY, that philosophy which proceeds on experiments; which deduces the laws of nature, and the properties and powers of bodies, and their actions upon each other, from sensible experiments and observations. The business of experimental philosophy is to inquire into and to investigate the reasons and causes of the various appearances or phænomena of nature; and to make the truth or probability of them obvious and evident to the senses, by plain, undeniable, and adequate experiments, representing the several parts of the grand machinery and agency of nature.

In our inquiries into nature, we are to be conducted by those rules and maxims which are found to be genuine, and consonant to a just method of physical reasoning; and these rules of philosophizing are by the greatest master in science, sir Isaac Newton, reckoned four, which are as follows:

1. More causes of natural things are not to be admitted, than are both true, and sufficient to explain the phænomena: for nature does nothing in vain, but is simple, and delights not in superfluous causes of things.

2. And, therefore, of natural effects of the same kind, the same causes are to be assigned, as far as it can be done; as of respiration in man and beasts, of the descent of stones in Europe and America, of light in a culinary fire and in the sun, and of the reflection of light in the earth and in the planets.

3. The qualities of natural bodies which cannot be increased or diminished, and agree to all bodies on which experiments can be made, are to be reckoned as the qualities of all bodies whatever; thus, because extension, divisibility, hardness, impenetrability, mobility, the vis inertiæ, and gravity, are found in all bodies which fall under our cognizance or inspection, we may justly conclude they belong to all bodies whatever, and are therefore to be esteemed the original and universal properties of all natural bodies.

4. In experimental philosophy, propositions collected from the phænomena by induction, are to be deemed (notwithstanding contrary hypotheses) either exactly or very nearly true, till other phænomena occur, by which they may be rendered either more accurate, or liable to exception. This ought to be done, lest arguments of induction should be destroyed by hypotheses.

These four rules of philosophizing are premised by sir Isaac Newton to his third book of the Principia; and more particularly explained by him in his Optics, where he exhibits the method of proceeding in philosophy, the first part of which is as follows:

As in mathematics, so in natural history, the investigation of difficult things, by way of analysis, ought always to precede the method of composition. This analysis consists in making experiments and observations, and in drawing general conclusions from them by induction (*i. e.* reasoning from the analogy of things by natural consequence); and admitting no objections against the conclusions, but what are taken from experiments or certain truths. And although the reasoning from experiments and observations, by induction, is no demonstration of general conclusions, yet it is the best mode of reasoning which the nature of things admits of, and may be looked on as so much the stronger, by how much the induction is more general; and if no exception occurs from phænomena, the conclusion may be pronounced generally; but if at any time afterwards, any exception shall occur from experiments, it may then be pronounced with such exceptions; by this way of analysis we may proceed from compounds to ingredients, and from motions to the causes producing them; and in general from effects to their causes, and from particular causes to more general ones, till the argument ends in the most general; this is the method of analysis. And that of synthesis, or composition, consists in assuming causes, discovered and established as principles, and by them explaining the phænomena proceeding from them, and proving the explanations. Though the whole history of nature is open to the researches of experimental philosophy, yet its principal branches may be accounted, attraction, gravitation, the laws of matter and motion, magnetism, optics, electricity, pneumatics, hydrostatics, hydraulics, and mechanics.

EXPERIMENTUM CRUCIS, a leading, or decisive experiment; thus termed, either on account of its being like a cross, or direction post, placed in the meeting of several roads, guiding men to the true knowledge of the nature of that thing they are inquiring after; or, on account of its being a kind of torture, whereby the nature of the thing is in a manner extorted by force.

EXPIATION, *great day of*, an annual solemnity of the Jews, upon the tenth day of the month Tisri, which answers to our September. On this occasion the high priest laid aside his breatplate and embroidered ephod,

above 82.5°, or cooled below 12.5°. This rule will give the reader a more precise idea of the rate at which water expands, when heated or cooled, than a bare inspection of the table could do.

A considerable number of liquids has been tried to ascertain whether any of them, like water, have a temperature in which their density is a maximum, and which expand when cooled below that temperature. Sulphuric acid has no such point, neither have the oily bodies; but some solutions of salt in water begin to expand before they become solid. These solutions, however, when cooled down sufficiently, crystallize with such rapidity, that it is extremely difficult to be certain of the fact, that they really do begin to expand before they crystallize.

That class of bodies which undergo an expansion when they change from a liquid to a solid body by the diminution of temperature, is very numerous. Not only water when converted into ice undergoes such an expansion, but all bodies which by cooling assume the form of crystals.

The prodigious force with which water expands in the act of freezing has been long known to philosophers. Glass bottles filled with water are commonly broken in pieces when the water freezes. The Florentine academicians burst a brass globe whose cavity was an inch in diameter, by filling it with water and freezing it. The force necessary for this effect was calculated by Muschenbroeck at 27720 lbs. But the most complete set of experiments on the expansive force of freezing water are those made by major Williams at Quebec, and published in the second volume of the Edinburgh Transactions. This expansion has been explained, by supposing it the consequence of a tendency which water, in consolidating, is observed to have to arrange its particles in one determinate manner, so as to form prismatic crystals, crossing each other at angles of 60° and 120°. The force with which they arrange themselves in this manner must be enormous, since it enables small quantities of water to overcome so great mechanical pressures. Various methods have been tried to ascertain the specific gravity of ice at 32°; that which succeeded best was to dilute spirits of wine with water till a mass of solid ice put into it remained in any part of the liquid without either sinking or rising. The specific gravity of such a liquid is 0.92, which of course is the specific gravity of ice, supposing the specific gravity of water at 60° to be 1. This is an expansion much greater than water experiences even when heated to 212°. We see from this, that water, when converted into ice, no longer observes that equable expansion measured by Mr. Dalton, but undergoes a very rapid and considerable augmentation of bulk.

The very same expansion is observed during the crystallization of most of the salts; all of them at least which shoot into prismatic forms. Hence the reason that the glass vessels in which such liquids are left, usually break to pieces when the crystals are formed.

This expansion of these bodies cannot be considered as an exception to the general fact, that bodies increase in bulk when heat is added to them, for the expansion is the consequence, not of the diminution of heat, but of the change in their state from liquids to solids, and the new arrangment of their particles which accompanies or constitutes that change.

It must be observed, however, that all bodies do not expand when they become solid. There are a considerable number which diminish in bulk; and in these the rate of diminution in most cases is rather increased by solidification. When liquid bodies are converted into solids, they either form prismatic crystals, or they form a mass in which no regularity of arrangement can be perceived. In the first case, expansion accompanies solidification; in the second place, contraction accompanies it. Water and all the salts furnish instances of the first, and tallow and oils are examples of the second. In these last bodies the solidification does not take place instantaneously, as in water and salts, but slowly and gradually; they first become viscid, and at last quite solid. Most of the oils, when they solidify, form very regular spheres. The same thing happens to honey, and to some metals. It has been thought that all combustible liquids contract, when they become solid, while incombustible liquids expand; but there are exceptions to this rule. Sulphuric acid does not by congelation alter its appearance; but cast iron, and perhaps sulphur also, expand in the act of congealing.

EX PARTE, a term used in the court of chancery, when a commission is taken out and executed by one side or party only, upon the other parties neglecting or refusing to join therein. When both the parties proceed together, it is called a joint commission.

Ex parte talis, a writ that lies for a bailiff or receiver, that having auditors assigned to pass his accounts, cannot procure from them reasonable allowance, but is cast into prison; in which case the practice is to sue this writ out of the chancery, directed to the sheriff to take the four mainpernors to bring his body before the barons of the exchequer, at a certain day, and to warn the lord to appear at the same time.

EXPECTANT, in law, signifies having relation to, or depending on; thus, where land is given to a man and his wife, and to their heirs, they have a fee simple estate; but if it be given to them and the heirs of their bodies begotten, they have an estate tail, and a fee expectant, which is opposed to fee simple.

EXPECTATION, in the doctrine of chances, is applied to any contingent event, upon the happening of which some benefit, &c. is expected. This is capable of being reduced to the rules of computation; for a sum of money in expectation when a particular event happens, has a determinative value before that event happens. Thus, if a person is to receive any sum as 10*l.* when an event takes place which has an equal chance or probability of happening and failing, the value of the expectation is half that sum, or 5*l.*; but if there are three chances for failing, and only one for its happening, or one chance only in its favour out of all the four chances, then the probability of its happening is only one out of four, or $\frac{1}{4}$, and the value of the expectation is but $\frac{1}{4}$ of 10*l.* which is only 2*l.* 10*s.* or half the former sum. And in all cases, the value of the expectation of any sum is found by multiplying that sum by the fraction expressing

the probability of obtaining it. So the value of the expectation on 100*l.* when there are three chances out of five for obtaining it, or when the probability of obtaining it is 3-fifths, is 3-fifths of 100*l.* which is 60*l.* And if s be any sum expected on the happening of an event, h the chances for that event happening, and f the chances for its failing: then, there being h chances out of $f + h$ for its happening, the probability will be $\frac{h}{f + h}$, and the value of the expectation is $\frac{h}{f + h} \times s$. See CHANCES.

EXPECTATION *of Life*, the share of life due to a person of a given age, according to a table of mortality. The most obvious sense of the term, is certainly, "the particular number of years which a life of a given age has an equal chance of enjoying:" this is the time that a person may reasonably expect to live; for the chances against his living longer are greater than those for it; and therefore, he cannot entertain an expectation of living longer, consistently with probability; but this period does not coincide with what the writers on Life Annuities call the Expectation of Life, except on the supposition of an uniform decrease in the probabilities of life, as Mr. Simpson has observed in his Select Exercises; and Dr. Price adds, that even on this supposition, it does not coincide with what is called the expectation of life, in any case of joint lives; he therefore defines it more accurately to be, "The mean continuance of any given single, joint, or surviving lives, according to any given table of observations:" that is, the number of years which, taking them one with another, they actually enjoy, and may be considered as sure of enjoying; those who live or survive beyond that period, enjoying as much more time in proportion to their number, as those who fall short of it enjoy less.

The particular proportion that becomes extinct every year, out of the whole number constantly existing together of single or joint lives, must, whenever this number undergoes no variation, be the same with the expectation of those lives, at the time when their existence commenced. Thus, was it found in any town or district, where the number of births and burials are equal, that a 20th or a 30th part of the inhabitants die annually, it would appear, that 20 or 30 was the expectation of a child just born in that town or district; and if a 13th part of all the inhabitants of the age of 60 years and upwards die annually, the expectation of a person of 60 years of age is 13 years. These expectations, therefore, for all single lives, are easily found by a Table of Mortality, showing the number that die annually at all ages, out of a given number alive at those ages; and the general rule for this purpose is, "to divide the sum of all the living in the table, at the age whose expectation is required, and at all greater ages, by the sum of all that die annually at that age, and above it; or, which is the same, by the number in the table of the living at that age: and half unity subtracted from the quotient will be the required expectation. Thus the sum of all the living at the age of 60 and upwards, in Table I, is 27965, which divided by 2038, the number living at that age, and the quotient less half unity, gives 13.21, the expectation of 60, as in table II.

TABLE I.

Showing the Probabilities of the Duration of Human Life, deduced from the Register of Mortality at Northampton.

Age.	Persons living.	Decrem. of Life.	Age.	Persons living.	Decrem. of Life.
0	11650	3000	49	2936	79
1	8650	3367	50	2857	81
2	7283	502	51	2776	82
3	6781	335	52	2694	82
4	6446	197	53	2612	82
5	6249	184	54	2530	82
6	6065	140	55	2448	82
7	5925	110	56	2366	82
8	5815	80	57	2284	82
9	5735	60	58	2202	82
10	5675	52	59	2121	82
11	5623	50	60	2038	82
12	5573	50	61	1956	82
13	5523	50	62	1874	81
14	5473	50	63	1793	81
15	5423	50	64	1712	80
16	5373	53	65	1632	80
17	5320	58	66	1552	80
18	5262	63	67	1472	80
19	5199	67	68	1392	80
20	5132	72	69	1312	80
21	5060	75	70	1232	80
22	4985	75	71	1152	80
23	4910	75	72	1072	80
24	4835	75	73	992	80
25	4760	75	74	912	80
26	4685	75	75	832	80
27	1610	75	76	752	77
28	4535	75	77	675	73
29	4460	75	78	602	68
30	4385	75	79	534	65
31	4310	75	80	469	63
32	4235	75	81	406	60
33	4160	75	82	346	57
34	4085	75	83	289	55
35	4010	75	84	234	48
36	3955	75	85	186	41
37	3860	75	86	145	34
38	3785	75	87	111	28
39	3710	75	88	83	21
40	3635	76	89	62	16
41	3559	77	90	46	12
42	3482	78	91	34	10
43	3404	78	92	24	8
44	3326	78	93	16	7
45	3248	78	94	9	5
46	3170	78	95	4	3
47	3092	78	96	1	1
48	3014	78			

The probability that a given life shall continue any number of years, or reach a given age, is the fraction, whose numerator is the number of living in the table opposite to the given age; and denominator, the number opposite to the present age of the given life. Thus, the probability that a life of 30 shall attain to 40, or live 10 years, is $\frac{3635}{4385}$. The difference between this fraction and unity gives the probability that the event will *not*

happen; the probability that a life of 30 will not live 10 years, is therefore $\frac{750}{4335}$, consequently the odds of living to dying in this period, are nearly 5 to 1. The probability that a person of 21 shall attain to 51, appears by the table to be $\frac{2530}{5060}$, or an even chance.

TABLE II.

Showing the Expectation of Human Life at every Age, according to the Probabilities in the preceding Table.

Age.	Expectation.	Age.	Expectation.	Age.	Expectation.
0	25,18	33	26,72	66	10,42
1	32 74	34	26,20	67	9,96
2	37,79	35	25,68	68	9,50
3	39.55	36	25,16	69	9,05
4	40,58	37	24,64	70	8,60
5	40,84	38	24,12	71	8,17
6	41,07	39	23,60	72	7,74
7	41,03	40	23,08	73	7,33
8	40,79	41	22,56	74	6,92
9	40,36	42	22,04	75	6,54
10	39,78	43	21,54	76	6.18
11	39,14	44	21,03	77	5,83
12	38,49	45	20,52	78	5,48
13	37,83	46	20,02	79	5,11
14	37,17	47	19,51	80	4,75
15	36,51	48	19,00	81	4,41
16	35,85	49	18,49	82	4,09
17	35,20	50	17,99	83	3,80
18	34,58	51	17,50	84	3,58
19	33.99	52	17,02	85	3,37
20	33,43	53	16,54	86	3,19
21	32,90	54	16,06	87	3,01
22	32,39	55	15,58	88	2,86
23	31,88	56	15,10	89	2,66
24	31,36	57	14,63	90	2,41
25	30,85	58	14,15	91	2,09
26	30,33	59	13,68	92	1,75
27	29 82	60	12,21	93	1,37
28	29,30	61	12,75	94	1,05
29	28.79	62	12,28	95	0,75
30	28.27	63	11,81	96	0,50
31	27,76	64	11,35		
32	27,24	65	10,88		

These tables are, for general use, the best that have been formed; but it is well known, that the duration of human life is much influenced by different situations; that it is greater in mountainous countries than in marshy districts; and that the country in general is much more favourable to the continuance of life than large towns. In proof of the latter assertion Dr. Price has observed, that in London the greater part of the natives die under three years of age, while in the country the greater part live to marry. The observations of Mr. Muret on the state of population in the Pays de Vaud, a district of the province of Bern in Switzerland, also confirm this remark, by showing that the greater part of the inhabitants of that province live many years beyound maturity. A comparison of the expectations of life will exhibit this difference in a striking point of view.

	London.	Vienna.	Berl'n.	Norwich.	Brandenberg.	Sweden	Holy Cross.
At Birth	18	$16\frac{1}{2}$	18	$23\frac{1}{4}$	$30\frac{3}{4}$	$34\frac{1}{2}$	34
Age 10	35	37	$37\frac{1}{4}$	$40\frac{1}{4}$	$42\frac{1}{4}$	45	46
20	29	$31\frac{1}{2}$	$30\frac{1}{4}$	$34\frac{1}{2}$	$34\frac{1}{2}$	38	$38\frac{3}{4}$
30	$23\frac{1}{2}$	$25\frac{1}{2}$	$25\frac{1}{4}$	29	$28\frac{3}{4}$	$31\frac{1}{4}$	$32\frac{3}{4}$
40	$19\frac{1}{2}$	$20\frac{1}{2}$	21	$23\frac{1}{4}$	$22\frac{3}{4}$	$24\frac{1}{2}$	$26\frac{1}{2}$
50	16	16	$16\frac{1}{2}$	$17\frac{1}{2}$	$16\frac{1}{2}$	$18\frac{1}{2}$	$20\frac{1}{2}$
60	$12\frac{1}{2}$	$11\frac{3}{4}$	$12\frac{1}{2}$	$12\frac{1}{4}$	$11\frac{1}{4}$	$12\frac{3}{4}$	$14\frac{3}{4}$
70	8	$8\frac{1}{4}$	$8\frac{3}{4}$	$8\frac{1}{4}$	$7\frac{1}{2}$	$7\frac{3}{4}$	10
80	5	$5\frac{1}{2}$	6	$5\frac{1}{4}$	5	$4\frac{1}{4}$	$5\frac{3}{4}$

Ages at which 1000 *Inhabitants die, in several principal Towns and Districts.*

	Stockholm.	Vienna.	Berlin.	London 1728 to 1737.	London 1771 to 1780.	Norwich.	Northampton.	Parish in Brandenberg	Sweden.	Vaud in Switzerland.
Under 10	653	673	519	590	593	560	513	423	388	347
10 to 20	39	40	26	50	46	46	47	50	49	43
20 to 30	56	40	80	59	56	53	64	41	61	47
30 to 40	64	48	86	72	66	52	64	54	60	57
40 to 50	61	52	73	70	72	57	67	58	74	75
50 to 60	50	52	80	57	61	65	70	92	92	117
60 to 70	41	48	63	48	51	74	69	116	118	146
70 to 80	29	32	50	31	38	62	66	122	119	122
80 and upwards	7	13	23	23	17	31	40	44	56	46

Proportion of Inhabitants dying annually.

In London - - - -	1 in $20\frac{3}{4}$
Edinburgh - - -	1 in $20\frac{4}{5}$
Dublin - - - -	1 in 22
Stockholm - - - -	1 in 19
Vienna - - - -	1 in $19\frac{1}{2}$
Rome - - - -	1 in $21\frac{1}{2}$
Amsterdam - - -	1 in 24
Norwich - - - -	1 in $24\frac{1}{2}$

Northampton - - -	1 in $26\frac{2}{5}$
Liverpool - - - -	1 in 27
Manchester - - -	1 in 28
Savannah in Georgia - -	1 in $31\frac{7}{10}$
Wirtemburgh - - -	1 in 32
Sweden - - - -	1 in 35
Kingdom of Naples - -	1 in $37\frac{1}{3}$
Parish in Brandenberg -	1 in 45
Pays de Vaud - - -	1 in 45
Philadelphia - - -	1 in 45
Ackworth in Yorkshire -	1 in 47
Salem in Massachusetts -	1 in 47
Island of Madeira - -	1 in 50
Corfe-castle, Dorset - -	1 in $56\frac{1}{3}$

These comparisons strongly show the baleful influence of great cities, in shortening human life. The irregular modes of life, the luxuries, debaucheries, and pernicious customs, which prevail much more in towns than in the country; and the foulness of the air, which is rendered in a great degree unfit for respiration; are undoubtedly the causes which produce this fatal effect.

EXPECTORANTS. See Pharmacy.

EXPECTORATION, the act of evacuating or bringing up phlegm, or other matters, out of the trachea and lungs, by coughing, &c.

EXPENDITORS, the persons who disburse or expend the money collected by the tax for repairs of sewers, after the same is paid into their hands by the collectors, as ordered by the commissioners, and for which they are to render accounts when required.

EXPENSIS MILITUM LEVANDIS, a writ anciently directed to the sheriff for levying the allowance for knights of the shire; and expensis militum non levandis, was a writ to hinder the sheriff from levying such allowance upon lands that held in ancient demense.

EXPERIMENTAL PHILOSOPHY, that philosophy which proceeds on experiments; which deduces the laws of nature, and the properties and powers of bodies, and their actions upon each other, from sensible experiments and observations. The business of experimental philosophy is to inquire into and to investigate the reasons and causes of the various appearances or phænomena of nature; and to make the truth or probability of them obvious and evident to the senses, by plain, undeniable, and adequate experiments, representing the several parts of the grand machinery and agency of nature.

In our inquiries into nature, we are to be conducted by those rules and maxims which are found to be genuine, and consonant to a just method of physical reasoning; and these rules of philosophizing are by the greatest master in science, sir Isaac Newton, reckoned four, which are as follows:

1. More causes of natural things are not to be admitted, than are both true, and sufficient to explain the phænomena: for nature does nothing in vain, but is simple, and delights not in superfluous causes of things.

2. And, therefore, of natural effects of the same kind, the same causes are to be assigned, as far as it can be done; as of respiration in man and beasts, of the descent of stones in Europe and America, of light in a culinary fire and in the sun, and of the reflection of light in the earth and in the planets.

3. The qualities of natural bodies which cannot be increased or diminished, and agree to all bodies on which experiments can be made, are to be reckoned as the qualities of all bodies whatever; thus, because extension, divisibility, hardness, impenetrability, mobility, the vis inertiæ, and gravity, are found in all bodies which fall under our cognizance or inspection, we may justly conclude they belong to all bodies whatever, and are therefore to be esteemed the original and universal properties of all natural bodies.

4. In experimental philosophy, propositions collected from the phænomena by induction, are to be deemed (notwithstanding contrary hypotheses) either exactly or very nearly true, till other phænomena occur, by which they may be rendered either more accurate, or liable to exception. This ought to be done, lest arguments of induction should be destroyed by hypotheses.

These four rules of philosophizing are premised by sir Isaac Newton to his third book of the Principia; and more particularly explained by him in his Optics, where he exhibits the method of proceeding in philosophy, the first part of which is as follows:

As in mathematics, so in natural history, the investigation of difficult things, by way of analysis, ought always to precede the method of composition. This analysis consists in making experiments and observations, and in drawing general conclusions from them by induction (*i. e.* reasoning from the analogy of things by natural consequence); and admitting no objections against the conclusions, but what are taken from experiments or certain truths. And although the reasoning from experiments and observations, by induction, is no demonstration of general conclusions, yet it is the best mode of reasoning which the nature of things admits of, and may be looked on as so much the stronger, by how much the induction is more general; and if no exception occurs from phænomena, the conclusion may be pronounced generally; but if at any time afterwards, any exception shall occur from experiments, it may then be pronounced with such exceptions; by this way of analysis we may proceed from compounds to ingredients, and from motions to the causes producing them; and in general from effects to their causes, and from particular causes to more general ones, till the argument ends in the most general; this is the method of analysis. And that of synthesis, or composition, consists in assuming causes, discovered and established as principles, and by them explaining the phænomena proceeding from them, and proving the explanations. Though the whole history of nature is open to the researches of experimental philosophy, yet its principal branches may be accounted, attraction, gravitation, the laws of matter and motion, magnetism, optics, electricity, pneumatics, hydrostatics, hydraulics, and mechanics.

EXPERIMENTUM CRUCIS, a leading, or decisive experiment; thus termed, either on account of its being like a cross, or direction post, placed in the meeting of several roads, guiding men to the true knowledge of the nature of that thing they are inquiring after; or, on account of its being a kind of torture, whereby the nature of the thing is in a manner extorted by force.

EXPIATION, *great day of*, an annual solemnity of the Jews, upon the tenth day of the month Tisri, which answers to our September. On this occasion the high priest laid aside his breatplate and embroidered ephod,

as being a day of humiliation. He first offered a bullock and a ram for his own sins, and those of the priests; then he received from the heads of the people two goats for a sin-offering, and a ram for a burnt-offering, to be offered in the name of the whole multitude. It was determined by lot which of the goats should be sacrificed, and which set at liberty. After this he perfumed the sanctuary with incense, and sprinkled it with blood; then, coming out, he sacrificed the goat upon which the lot had fallen. This done, the goat which was to be set at liberty, being brought to him, he laid his hands upon its head, confessed his sins and the sins of the people, and then sent him away into some desert place: it was called azazel, or the scape goat.

EXPILATION, among civilians, the carrying off or sequestering something belonging to an inheritance, before the heir had intermeddled with it.

Expilation also denoted a robbery committed by night, and was so called from the robbers stripping people of their clothes.

EXPLOSION, in natural philosophy, a sudden and violent expansion of an aerial or other elastic fluid, by which it instantly throws off any obstacle that happens to be in the way, sometimes with incredible force, and in such a manner as to produce the most astonishing effects upon the neighbouring objects. Explosion differs from expansion, in this: that the latter is a gradual and continued power, acting uniformly for some time; whereas the former is always sudden, and only of a momentary duration. The expansions of solid substances do not terminate in violent explosions, on account of their slowness, and the small space through which the metal, or other expanding substance, moves, though their strength may be equally great with that of the most active aerial fluids. Thus we find, that though wedges of wood, when wetted, will cleave solid blocks of stone, they never throw them to any distance, as is the case with gunpowder. On the other hand, it is seldom that the expansion of any elastic fluid bursts a solid substance, without throwing the fragments of it to a considerable distance, the effects of which are often very terrible. The reasons of this may be comprised in the two following particulars. 1. The immense velocity with which the aerial fluids expand, when affected by a considerable degree of heat. 2. Their celerity in acquiring heat, and being affected by it, which is much superior to that of solid substances. Thus air, heated as much as iron when brought to a white heat, is expanded to four times its bulk; but the metal itself will not be expanded the 500th part of that space. In the case of gunpowder, which is a violent and well-known explosive substance, the velocity with which the flame moves is calculated by Mr. Robins, in his treatise upon Gunnery, to be no less than 7000 feet in a second, or little less than 79 miles per minute. Hence the impulse of the fluid is inconceivably great, and the obstacles on which it strikes are hurried off with vast velocity, though much less than that just mentioned; for a cannon-ball, with the greatest charge of powder that can be conveniently given, does not move at a greater rate than 2400 feet per second, or little more than 27 miles per minute. The velocity of the ball again is promoted by the sudden propagation of the heat through the whole body of the air, as soon as it is extricated from the materials of which the gunpowder is made, so that it is enabled to strike all at once, and thus greatly to augment the momentum of the ball. It is evident that this contributes very much to the force of the explosion, by what happens when powder is wetted or mixed with any substance, which prevents it from taking fire all at once. In this case the force of the explosion, even when the same quantity of powder is made use of, is not to be compared with that of dry powder.

We may conclude, upon these principles, that the force of an explosion depends, 1. on the quantity of elastic fluid to be expanded; 2. on the velocity it acquires by a certain degree of heat; and 3. on the celerity with which the degree of heat affects the whole of the expansile fluid. These three take place in the greatest perfection where the electric fluid is concerned, as in cases of lightning, earthquakes, and volcanoes. This fluid pervades the whole system of nature; its expansion is nothing else than its motion from a centre towards a circumference, for it does not seem capable of any proper expansion by a separation of its parts like any other fluid. Hence, when it begins to expand in this manner, the motion is propagated through it, with a velocity far exceeding that of any other fluid whatever. Thus, even when the quantity is excessively small, as when an electric spark is sent through a glass full of water or of oil, the expansion is so violent as to dissipate the glass into innumerable fragments, with great danger to the by-standers. In violent lightning, when the electric fluid is much concentrated, the strength of the explosion is proportionable to the quantity. Every one has heard of the prodigious effects of lightning when it happens to strike buildings, trees, or even the most solid rocks; and in some cases, where the quantity of electricity is still greater than in any flash of lightning, we hear of still more tremendous consequences ensuing. Dr. Priestley gives an instance of a large fire-ball rolling on the surface of the sea, which, after rising up to the top-mast of a ship of war, burst with such violence, that the explosion resembled the discharge of hundreds of cannons fired at once. Great damage was done by it; but there is not the least doubt that most of its force was spent on the air, or carried down to the sea by the mast and iron-work of the ship. Indeed, considering that in all cases a great part of the force of electric explosions is dissipated in this manner, it may justly be doubted whether they can be measured by any method applicable to the mensuration of other forces. Even in artificial electricity the force is prodigiously great, insomuch that Dr. Van Marum calculated that of the great battery belonging to the machine in Teyler's museum to be upwards of 900 pounds.

Whenever the electrical fluid acts like common fire, the force of the explosions, though exceedingly great, is capable of mensuration, by comparing the distances to which the bodies are thrown with their weight. This is most evident in volcanoes, where the projections of the burning rocks and lava manifest the greatness of the power, at the same time that they afford a method of measuring it. By means of the fire which kindles the volcanoes, the aerial fluids are suddenly restored to their elastic state; and not only so, but their natural elasticity is greatly augmented, so that the explosions take place with great violence. The case is the same with

gunpowder. The reason of the extreme quickness of the explosion of gunpowder, is, that it takes fire so readily by the intimate mixture and combustibility of all the materials. In volcanoes the explosions likewise follow one another very quickly, and are by no means inferior in strength to those of gunpowder; but here the quantity of vapour makes up for the comparative slowness with which it is affected by the heat. Thus, though we could not by any other means contrive to fire cannon in such quick succession as we can do with gunpowder, yet in the huge furnace of a volcano the elastic matter is supplied in such quantities, that the explosions are in a manner unremitting; and even in ordinary experiments the confinement of aerial vapours has often occasioned violent explosions in chemical vessels. Carbonic acid gas though heavier than most of the other aerial fluids, yet by its expansion contributes equally to the force of the explosion, as is evident, in that of pulvis fulminans. This is compounded of sulphur, saltpetre, and salt of tartar. The latter we know contains much carbonic acid gas; and it is probable that the violence of the explosion is occasioned by this air; for it is said that the greater quantity of it the alkaline salt contains, the greater force does it explode with.

Next in strength to the aerial vapours are those of aqueous and other liquids. The most remarkable effects of these are observed in steam-engines; but there is one particular case from which it has been inferred that aqueous steam is vastly stronger than the flame of gunpowder. This is when water is thrown upon melted copper; for here the explosion is so strong as almost to exceed imagination; and the most terrible accidents have been known to happen from such a slight cause as one of the workmen spitting in the furnace where copper was melting. Here, however, it is most probable that a decomposition of the water takes place, and on this supposition, the phænomenon is easily solved. The water being thrown in substance upon the melted copper, is decomposed by the violent heat; and one part of it adheres to the metal, thus converting it into a kind of calx, while the other is converted into inflammable air, which expanding suddenly, throws the melted metal about with the greatest violence by means of its reaction.

In order to understand the manner in which this is accomplished, we must consider some of the principles of gunnery laid down by Mr. Robins. One of these is, that though the air, in case of ordinary velocity, makes no great resistance, it is far otherwise where the velocity of the moving body becomes very great. In all cases of explosion also there is in the first instance a vacuum made by the exploding fluid; and consequently the weight of the atmosphere is to be overcome, which amounts to about 15 pounds on every square inch of surface. Supposing the surface of the exploding fluid then, on that of melted copper, to contain an area of four square inches, it meets with a resistance of 60 pounds from the atmosphere, and consequently communicates an equal pressure to the fluid metal. Even this must of consequence throw it about, unless the same pressure was exactly diffused over every part of the surface. But much more must this effect be increased by the immense velocity with which the fluid moves, and by which the resistance of the atmosphere is augmented in a prodigious degree. The elastic fluid generated is then confined not only by the fluid metal and sides of the furnace, but by the air itself, which cannot get out of the way, so that the whole resembles a cannon closed at the mouth, and filled with inflamed gunpowder. Hence not only the melted metal, but the furnace itself, and the adjacent walls of the building, are hurried off as they would be by the firing of a great quantity of gunpowder in a small space, and which is well known to produce analogous effects.

Dr. Black, in explaining the phænomenon in question, supposes that the mere heat of the metal applied to the aqueous steam produces the explosion; and in proof of this, alleges that copper imbibes a greater quantity of heat during fusion than any other metal. Aqueous steam, however, seems to be too slow for producing such sudden and violent effects. Explosions, it is true, will be occasioned by it, but then it must be confined for a very considerable time, whereas the effects of water thrown upon melted copper are instantaneous.

It must be observed, that in all cases, where a very hot body is thrown upon a small quantity of water in substance, an explosion will follow; but here the water is confined, and suddenly rarefied into steam, which cannot get away without throwing off the body which confines it. Examples of this kind frequently occur where masons, or other mechanics, are employed in fastening cramps of iron into stones; where, if there happens to be a little water in the hole into which the lead is poured, the latter will fly out in such a manner as sometimes to burn them severely. Terrible accidents of this kind have sometimes happened in foundries, when large quantities of melted metal have been poured into wet moulds. In these cases, the sudden expansion of the aqueous steam has thrown out the metal with violence; and if any decomposition has taken place at the same time, so as to convert the aqueous into an aerial vapour, the explosion must be still greater.

To this last kind of explosion we must refer that which takes place on pouring cold water into boiling or burning oil or tallow. Here the case is much the same whether we pour the oil on the water, or the water on the oil. In the former case, the water which lies at the bottom is rarefied into steam, and explodes; in the latter, it sinks down through the oil by its superior specific gravity, and explodes as it passes along. In either case, however, the quantity of aqueous fluid must be but small in proportion to that of the oil; a very great quantity would put out the flame, or destroy the heat, in whatever way we applied it.

Another kind of explosion is that which takes place in solid substances, where we can scarcely suppose either aqueous or aerial vapours to be concerned. The most remarkable of these are the volcanic bombs mentioned by sir William Hamilton in the great eruption of Vesuvius in 1779. They were large pieces of lava, which burst in pieces like bombs as they fell to the ground; but he does not inform us whether their bursting was attended with any great violence or not. Indeed, amidst such scenes of horror, and the continual tremendous explosions of the volcano, smaller phænomena of this kind would probably be overlooked.

The only other kind of explosion we have to take notice of, is that produced by hydrogen and oxygen gases,

The countries to which the above goods were exported were as follows:

	Livres.
To Spain	62,441,400
Batavian republic	37,751,600
Ligucian republic	23,010,700
Helvetian republic	38,809,100
Denmark, Sweden, Prussia, and the Hans towns	32,969,700
The United States of America	557,700
The Levant, Sardinia, Italy, Portugal, Germany, and other states then at war with France	76,035,400
Total	271,575,600

The commerce of the United States of America has already advanced to an extent which rivals that of some of the principal states of Europe, and, in all probability, will materially affect many of the long-established channels of trade. The destination of the exports of the United States is principally to the West Indians, Great Britain, France, Holland, and Spain; but some smaller branches of their commerce begin to appear in all the trading parts of the world. The following statement shows the proportions of the exports of 1804 to the dominions of each power:

	Dollars.
To Great Britain and Ireland	12,206,501
the British colonies	9,623,301
Holland and the Dutch colonies	16,447,417
France and colonies	12,776,111
Spain and colonies	6,728,125
Hamburgh, Bremen, &c.	4,475,007
Denmark and colonies	3,346,623
Sweden`	691,975
Prussia	1,186,116
Portugal and colonies	2,496,858
Italy	1,671,149
Trieste, and other Austrian ports	333,798
Europe generally	620,891
Turkey, the Levant, and Egypt	44,646
Morocco and the Barbary states	9,333
Cape of Good Hope	167,917
Africa generally	349,036
China	198,601
East Indies generally	796,316
South Seas	10,000
North-west coast of America	196,059
West Indies generally	3,324,294
Total	77,699,074

This total is more than double the amount of the exports of America ten years prior to the above period; and the whole increase of the trade of the States since they ceased to be British colonies, has been such as never before took place in any country. The proportion of the exports, consisting of produce or manufactures of the United States, and of foreign merchandize, was as follows:

	Dollars.
Domestic produce	41,467,477
Foreign	36,231,597
Total	77,699,674

On converting the totals of the accounts of the exports of France and America into British money, their respective amounts will stand thus:

	L.
Exports of Great Britain in 1800	43,152,019
Exports of France in 1800	11,315,650
Exports of the American States in 1804	17,482,291

Had the comparison been made with the real value of the exports of Great Britain instead of the custom-house value, the superior extent of our foreign trade would have appeared still more striking.

EXPOSITION, in general, denotes the setting a thing open to public view: thus it is the Romanists say, the host is exposed, when shown to the people.

EX POST FACTO, in law, something done after another: thus an estate granted may be good by matter ex post facto, that was not so at first, as in case of election.

A law is said to be ex post facto when it is enacted to punish an offence committed before the passing of the law. Such a proceeding is held to be against the constitution of England.

EXPRESSED OILS, in chemistry, such oils as are obtained from bodies only by pressing. See Oil.

EXPRESSION, in chemistry, or pharmacy, denotes the act of pressing out the juices or oils of vegetables, which is one of the three ways of obtaining them; the other two being by infusion and decoction. See Pharmacy.

Expression, in painting, is the distinct exhibition of character in the general object of the work, or of sentiment in the characters or persons represented.

In the latter case it consists either in representing the body in general and all its parts severally, in actions most peculiarly suitable to the design of the picture, and marking thereby the emotions of the soul in the various figures, or in pourtraying in the face the appearances of the passions. In this sense the term expression has been frequently confounded with passion; but the former implies a representation of its object agreeably to its nature and character, and to the office it holds on the picture; while the latter denotes merely a particular turn or motion of the body, or of the muscles and features of the face, which marks any violent agitation of the soul: so that every passion is an expression, but not every expression a passion.

Expression, says Le Brun, is a lively and natural resemblance of the objects which we are to represent. It is a necessary ingredient in every part of painting, and without it no picture can be perfect, as it is that which describes the true characters of things. It is by expression that the different natures of bodies are distinguished, that the figures seem to have motion, and that every thing counterfeited appears to be real.

Expression subsists as well in the colouring as in the design; it is to be observed in the representation of landscapes, as well as in the general composition of figures.

All substances, whether animate or inanimate, are capable of expression. The skill of the painter exhibits the hardness of one substance and the softness of another, its smoothness or roughness, its dryness or moistness, clearness or opaqueness, &c. in characters which cannot be mistaken.

Expression being therefore a representation of things according to their character, may be considered either with respect to the subject in general, or to the passions peculiarly relative to it.

1st. With regard to the subject; it is first requisite that all and every part of the composition should be so adapted to the general character of the subjects that they should conspire to impress at the same moment one distinct sentiment or idea. Thus, for example, in a picture designed to give the representation of a joyful or peaceful event, every object that is introduced should be of a pleasing or tranquil kind. If the subject be taken from history, its particular nature and character must be diffused through every part of the work; but wherever any circumstance occurs, which counteracts or diminishes the general sentiment raised by the event represented, the insertion of such circumstance will, proportionably to its magnitude, destroy the general expression of the picture.

Extraneous incidents are frequently introduced for the purpose of diversifying and giving variety to the expression; but they must be such as are neither contrary to the truth of the history, nor to the principal design of the subject.

Expression, in a picture, will then be perfect when every part of the picture is not only fit and appropriate to the subject, but when no one part of it could without evident impropriety be transferred to any other subject.

The agreement of the whole ought to be particularly regarded, not only in the actions of the figures, but in the back-ground, light and shade, and colouring. Whatever is the general character of the subject, whether serene, joyous, melancholy, grave, solemn, or terrible, the picture should discover that character to the first glance of the spectator. The nativity of a Saviour, his resurrection or ascension, must be distinguished from his crucifixion or his interment, as much by the general hue of the picture, the accessory ornaments, back-ground, &c. as by the action of the figures. In viewing same of the finest religious subjects of the Italian school, sentiments of awe and devotion have been often experienced to be amongst the first impressions made on the spectator, previous to his examination of the particular actions or countenances of the figures, and therefore evidently produced by the general distribution of the composition, or the general tone of the colouring. The works of Ludovico Caracci are justly celebrated by sir J. Reynolds in his academic discourses, for their powerful effect in the latter point.

In the admirable cartoon by Raffaelle, of St. Paul preaching at Athens, the expression of the whole work is just and strong. The dignified air of the apostle impresses the spectator with reverence. His action is awful and authoritative without excess or extravagance: it is an action which assures us that he, who uses it, speaks with a power of conviction. The different sentiments of his audience are exhibited with equal skill and good sense. Some of his hearers appear angry, some malicious, some attentive, some reasoning with themselves on his doctrines, some disputing their truth, and some convinced. The very back-ground has its meaning: it contributes to the demonstration or expression of that superstition, against which the inspired orator directed his eloquence. In the power of distinct, peculiar, and appropriate expression, no one has ever raised himself above Raffaelle, scarcely any one has ever equalled him.

There are often certain little circumstances which contribute to the expression of the general subject, and of these also no painter ever availed himself more than Raffaelle; witness the burning lamps, in the cartoon of the Apostles healing at the beautiful Gate of the Temple, where they have the effect of expressing the holy uses, no less than the magnificence, of the building in which they are hung.

The robes or other habits of the figures, their attendants, their engines of authority, crowns, maces, swords; or, in humble life, their various implements of labour, crooks, scythes, &c. all contribute to the expression of character.

There are also various kinds of accessory aids, which form a mode of artificial expression, indulged to painters, and practised by them. To express the sensations of the mind of Christ, when in agony a short while previous to his crucifixion, Baroccio has not only represented the angel offering him the cup of bitterness, but has painted in the back-ground the cross encircled with flames.

In the same manner in the cartoon where the people of Lycaonia are going to offer sacrifices to St. Paul and Barnabas, Raffaelle has shown the cause of their offerings, by adventitious figures. In the fore-ground, the man who had been healed of lameness by those apostles, is the most eager to express his sense of the miraculous power exercised by them, and the individuality of this character is marked not only by a crutch on the ground under his feet, but by the more singular circumstance of an old man taking up the skirt of his garment, looking on the limb which he may be supposed to have remembered in its former crippled state, and expressing his admiration and devotion.

Of the same kind was the artifice used by the Greek painter Timanthes (and so much admired by the ancients), to express the prodigious bulk of a cyclops. He placed round the sleeping monster several satyrs, supposed to be of the ordinary size of the human form, one of whom was measuring the thumb of the giant with his thyrsus, apparently with great caution, lest he should awake; others were running away, as if frightened; others gazing on him from a distance, as not daring to approach him.

Another artificial mode of expression, practised by painters, is the use of allegorical figures, representative of certain points of the subject. This art has also been derived from the ancients, who have left abundant examples of it; as in the bas-reliefs on the Antonine column at Rome, where the figure of Jupiter Pluvius is introduced to express the rain which fell when the Roman army was preserved by the prayers of the Theban legion. Raffaelle, in this manner, has personified the river Jordan in his design of the children of Israel pass-

ing across the river of that name: and has represented him as pushing back and restraining the course of the waters with his arm.

2dly. With regard to the passions and affections peculiar to the subject, the general rules consist in the proper division and distinction of them, as shown in brute or rational animals, in young or old, in male or female, in cultivated or savage.

The passions of brutes are few and simple; those of the rational animal many and various. The powers of expression in the one are more confined than in the other. A man can move his eyebrows more readily than the brutes, and can give greater variety to the direction of the eyes, &c.

Children and savages, less accustomed to the use of reason, express their passions more directly than cultivated men; the first necessarily, without habitual modes of disclosure or disguise.

Respecting the difference of age and sex, the expressions of vigorous manhood wear a freer, bolder, and more resolute appearance; those of women, and age, are more tender, reserved and feeble.

Condition or rank of life also demands a difference of expression. The demeanour of a magistrate, or other person invested with public honours, is more grave and reserved than that of the populace, whose external motions are, for the most part, rude and disorderly.

The several expressions of action, in running, striking, pointing, asking, forbidding, affirming, idling, avoiding, pursuing, starting, and many other modes, are obviously various, and require a fitness of attitude, and a proper delineation of the corresponding and assisting parts of the body, and other accessories.

For the painter of animals nothing is more necessary than the study of the characteristic expressions of the brute creation, which are severally as various as their species; not only on account of the singular diversity of qualities and instincts with which they are endowed, but of the different modes in which they exhibit passions of a similar nature. Expression in brute animals is, generally speaking, more displayed by attitude than by the features of the face, although, in part, this probably arises from our imperfect acquaintance with them.

As it is therefore in the human figure, and still more particularly in the human countenance, that expression is most effectually and exquisitely displayed, it is to man that our observations must be principally directed in this part of the subject, for the study of which there is no perfect school but that of nature. If the rules of expression generally given are found to agree with the experience of a careful observer of nature, they are good and useful; if not, they are to be followed with caution, or rejected wholly, as occasion shall dictate.

The affections of the soul may be expressed by attitude, and by countenance. There are few strong emotions of our minds which may not, in a great measure, be shown by the former. Fear, surprise, horror, admiration, humility, pride, and many other affections, are visible in the air and turn of the body; but as this mode of expression admits of a very extensive range, it is next to impossible to define the precise rules by which it is to be governed.

Next to the general action of the body, and turn or air of the head, the hands claim a principal share in the expression of our sentiments. It is by them we approve, refuse, entreat, admonish. The hands raised together towards heaven express devotion; folded they denote idleness, and sometimes despair; wringing the hands denotes grief; waving one hand from us, prohibition; extending it towards any one, acceptance and benevolent intentions; laying the fore-finger on the mouth enjoins silence; the same finger extended while the others are closed in the hand, shows and points to a particular object.

That by the countenance the particular and immediate disposition of our minds is indicated, is indisputable; and not this only, but our general qualities and capacities are to be found by the same index. Let two men, a wise man and a fool, be placed together, dressed and disguised as you please, one will never be mistaken for the other; nay, the distinction between them will be discernible at the first glance of the eye: and as these characters are most strongly stamped upon the face so as to be read by every spectator, when they are in the utmost extremes, they are proportionally impressed as they exist in a greater or less degree, and are legible accordingly, in proportion to the skill and sagacity of the reader.

In the same manner our good or ill-nature, our gentleness, ferocity, humility, pride, are discoverable in the countenance in all their various degrees. The lines and forms by which these general tendencies, or settled habits of our minds, are expressed, are, of all others, the most difficult to be defined. The reader will find many curious hints and essays concerning them in the works of Lavater.

With regard to the temporary affections of the mind, the following rules of expression are ordinarily given:

Although the passions of the soul may be expressed by the actions of the body, it is in the face that they are principally shown, and particularly in the turn of the eye, and motion of the eyebrows.

There are two ways of elevating the eyebrows; the one at the middle, which likewise draws up the corners of the mouth, and argues pleasurable emotions; the other at the point next the nose, which likewise draws up the middle of the mouth, and is the mark of grief and painful sensations.

The passions are all reducible to joy and sadness, either mixed or simple.

Joy causes a dilatation of all the parts of the face; the eyebrows rise in the middle, the eyes are half-open and smiling, the pupils sparkling and moist, the nostrils a little open, the cheeks full, the corners of the mouth drawn upwards, the lips red, the complexion lively, the forehead serene.

Passionate joy, proceeding from love, is shown by the forehead smooth and even, the eyebrows a little elevated on the side to which the pupil is turned, the eyes sparkling and open, the head inclined towards the object, the air of the face smiling, and the complexion ruddy.

Joy proceeding from desire, is expressed by the air and action of the body, the arms extending towards the object in uncertain and unquiet motions.

Sadness is expressed by the body being bent downwards, the head neglectfully reclined, the forehead

wrinkled, the eyebrows raised to the middle of the forehead, the eyes half-shut, the mouth a little open, the corners tending downwards, the under lip pointing and drawn back, the nostrils swelled and drawn downwards.

Sadness, mixed with fear, causes the parts to contract and palpitate, the members to tremble and fold up, the visage to be pale and livid, the point of the nostrils elevated, the pupil in the middle of the eye, the mouth opened at the sides, and the under-lip drawn back.

In sadness, mixed with anger, the motions are more violent, the parts all agitated, the muscles swelled, the pupil wild and sparkling, the point of the eyebrows fixed toward the nose, the nostrils open, the lips swelled and pressed down, the corners of the mouth a little open and foaming, the veins swelled and full, and the hair erect.

Sadness, mixed with despair, has a similar appearance to the last mentioned, only more excessive and disordered.

But, added to these general observations, every passion has its distinct form of expression, for which see the article PASSIONS.

It is remarkable that Leonardo da Vinci in his Treatise on Painting, has observed, that between the expression of laughing, and that of weeping, there is no difference in the motion of the features, either in the eyes, mouth, or cheeks, but in the brows only; those who weep, raising the brows and bringing them close together above the nose, and forming many wrinkles on the forehead, while those who laugh have them elevated and extended.

Of expression in sculpture, sir Joshua Reynolds has given it as his opinion that it is necessarily of a much more confined kind than in painting; an assertion which cannot be disputed, inasmuch as the materials of sculpture are more limited. He instances the celebrated group of Laocoon and his sons, in which he says the whole expression consits in the representation of bodily pain in general, and asserts that sculpture is incapable of admitting the mixed delineation of pain and parental affection.

This doctrine, if not highly questionable, certainly demands a greater degree of elucidation.

EXTASY, in medicine, a species of catalepsy, when a person perfectly remembers, after the paroxysm is over, the ideas he conceived during the time it lasted.

EXTEND, in law, signifies to value the lands or tenements of a person bound by a statute, &c. who has forfeited the same at such an indifferent rate, that by the yearly rent the creditor in time may be paid his debt. See EXTENT.

EXTENSION, in philosophy, one of the common and essential properties of a body, or that by which it possesses or takes up some part of universal space, which is called the place of that body.

EXTENSOR, an appellation given to several muscles, from their extending or stretching the parts to which they belong.

EXTENT, in law, is used in a double sense: sometimes it signifies a writ or command to the sheriff for the valuing of lands or tenements; and sometimes the act of the sheriff, or other commissioner, upon this writ; but most commonly it denotes an estimate or valuation of lands, and hence come our extended or rack rents. Every extent ought to be made on inquisition and verdict, without which the sheriff cannot legally execute the writ.

The cognisee, or party to whom the lands are delivered, has no absolute property in them, but is accountable to the cognisor according to the extended value only, not the real value. No seisin can be on an extent, nor may lands or goods be sold thereon.

EXTERMINATION, in general, the extirpating or destroying something. In algebra, surds, fractions, and unknown quantities, are exterminated by the rules for reducing equations. See ALGEBRA.

EXTINGUISHMENT, in law: wherever a right, title, or interest is destroyed, or taken away by the act of God, operation of law, or act of this party, this is called an extinguishment.

Of the extinguishment of rents.—If a lessor purchases the tenancy from his lessee, he cannot have both the rent and the land; nor can the tenant be under any obligation to pay the rent when the land, which was the consideration thereof, is returned by the lessor into his own hands; and this resumption or purchase of the tenantcy makes what is properly called an extinguishment of the rent.

As to the extinguishment of copyholds, it is laid down as a general rule, that any act of the copyholder, which denotes his intention to hold no longer of his lord, amounting to a determination of his will, is an extinguishment of his copyhold. Hutt. 81.

Of the extinguishment of common.—If a commoner release his common in one acre, it is an extinguishment of the whole common. Show. 350.

Of the extinguishment of debts.—A creditor's accepting a higher security than he had before is an extinguishment of the first debt; as if a creditor by simple contract accepts an obligation, this extinguishes the simple-contract debt. 1 Rol. Abr. 470 and 471.

EXTINGUISHMENT OF SERVICES. The lord purchases or accepts parcel of the tenantcy, out of which an entire service is to be paid or done; by this the whole service will be extinct; but if the service is pro bono publico, then no part of it shall be extinguished; and homage and fealty are not subject to extingushment by the lord's purchasing part of the land. 6 Rep. 105.

EXTINGUISHMENT OF WAYS. If a man has a highway as appendant, and after purchases the land wherein this way is, the way is extinct: though a way of necessity, to market, or to church, or to arable land, &c. is not extinguished by purchase of grounds, or unity of possession. 1 Inst. 155.

EXTORTION, signifies any oppression by colour or pretence of right; and in this respect it is said to be more heinous than robbery itself, as also that it is usually attended with the aggravating sin of perjury. Co. Lit. 368.

At common law extortion is severely punishable at the king's suit by fine and imprisonment, and by a removal from the office in the execution whereof it was committed. 31 Eliz. c. 5. And this statute adds a greater penalty than the common law gave; for hereby the plaintiff shall recover his double damages. 2 Inst. 210. See COLOUR OF OFFICE.

EXTRACT, in pharmacy, is a solution of the purer

parts of a mixed body inspissated, by distillation or evaporation, nearly to the consistence of honey. See PHARMACY.

EXTRACTION, in surgery, is the drawing any foreign matter out of the body by the hand, or by the help of instruments. See SURGERY.

EXTRACTION OF ROOTS, in algebra and arithmetic, the method of finding the root of any power or number. See ALGEBRA, and ARITHMETIC.

EXTRACTOR, in midwifery, an instrument, or forceps, for extracting children by the head. See MIDWIFERY.

EXTRA-JUDICIAL, is when judgment is given in a cause or case not depending in that court where such judgment is given, or wherein the judge has no jurisdiction.

EXTRA-PAROCHIAL, out of any parish; privileged or exempted from the duties of a parish. If a place is extra-parochial, and has not the face of a parish, the justices have no authority to send any poor person thither: possibly a place extra-parochial may be taxed in aid of a parish, but a parish shall not in aid of that. 2 Salk. 486.

EXTRAVAGANTES, those decretal epistles which were published after the Clementines. They were so called because, at first, they were not digested or ranged with the other papal constitutions, but seemed to be detached from the canon law. They continued to be called by the same name when they were afterwards inserted in the body of the canon law. The first extravagantes are those of John XXII. successor of Clement V.: the last collection was brought down to the year 1483, and was called the common extravagantes, notwithstanding that they were likewise incorporated with the rest of the canon law.

EXTRAVASATION, in contusions, fissures, depressions, fractures, and other accidents of the cranium, is when one or more of the blood-vessels that are distributed on the dura mater, are broken or divided, whereby there is such a discharge of blood as greatly oppresses the brain, and disturbs its offices; frequently bringing on violent pains and other mischiefs, and at length death itself, unless the patient is timely relieved. See SURGERY.

EXTREMES, in logic, the terms expressing the two ideas whose relation we inquire after in a syllogism.

EXTREME *and mean proportion*, in geometry, is when a line AB (Plate LIV. Miscel. fig. 88) is so divided in F, that the rectangle under the whole line AB, and the lesser segment FB, is equal to the square of the greater segment AF.

Let a square be formed upon the line AB, and one of its sides AC be equally divided in the point D; draw DB, and take the line DG equal to the line BD; then the square AGHF will be equal to the rectangle FE.

For since the line AC is equally divided in the point D, and is lengthened by the line AG, the rectangle CH, together with the square of the line AD, will (by 6. 2. El.) be equal to the square of the line DG or DB. But the square AE, with the square of the line AD, is also equal (47. 1.) to the square of the line DB. Therefore the square AE is equal to the rectangle CH. Taking then away from both the rectangle CF, the rectangle FE will be equal to the square FG.

But no number can be so divided into two parts, as is demonstrated by Clavius, in his commentaries upon lib. 9. of Euclid; which is evident enough thus: Let a be the number, and x the greater part; then the lesser part will be $a - x$, and so $aa - ax = xx$, and thence $x = \frac{a + a\sqrt{5}}{2}$; and since the square root of 5 cannot be had in numbers exactly, it is plain that the value of x partly consisting of the square root, multiplied by a, cannot be had exactly in numbers neither.

EXTREMES *conjunct and disjunct*. See TRIGONOMETRY, *spherical*.

EXUVIÆ, among naturalists, denote the cast-off parts or coverings of animals, as the skins of serpents, caterpillars, and other insects. See ERUCA.

EYE, in anatomy, the organ of sight, or that part of the body whereby visible objects are represented to the mind. See ANATOMY, OPTICS, and PHYSIOLOGY.

Motions of the eye are either external or internal. The external motion is that performed by its four straight and two oblique muscles, whereby the whole globe of the eye changes its situation or direction. The spherical figure of our eyes, and their loose connection to the edge of the orbit by the tunica conjunctiva, which is soft, flexible, and yielding, does excellently dispose them to be moved this or the other way, according to the situation of the object we could view. By the membranes the eye is connected to the edge of the orbit, which being soft and flexible, they do in such a manner as not in the least to impede its necessary motions; and that great quantity of fat placed all round the globe, betwixt it and the orbit, lubricates and softens the eye, and renders its motions more easy: hence arise the three following remarkable observations:

1. When nature has denied the head any motion, it is observable that she has, with great care and industry, provided for this defect. To this purpose belongs the surprising beautiful and curious mechanism observable in the immoveable eyes of flies, wasps, &c. They nearly resemble two protuberant hemispheres, each consisting of a prodigious number of other little segments of a sphere, all which segments are perforated by a hole, which may be called their pupil, in which this is remarkable; that every foramen, or pupil, is of a lenticular nature, so that we see objects through them topsy-turvy, as through so many convex glasses: they even become a small telescope, when there is a due focal distance between them, and the lens of the microscope by which they are viewed. Leuwenhoek's observations make it probable that every lens of the cornea supplies the place of the crystalline humour, which seems to be wanting in those creatures; and that each has a distinct branch of the optic nerve answering to it, upon which the images are pointed: so that as most animals are binocular, and spiders for the most part octonocular, so flies, &c. are multocular, having in effect as many eyes as there are perforations in the cornea, by which means (as other creatures with but two eyes are obliged, by the contraction of the muscles above-enumerated, to turn their eyes to objects) these have some or other of their pupils always ready placed towards objects nearly all around them, whence they are so far from being denied any benefit of this noble and most necessary sense of sight,

that they have probably more of it than other creatures, answering to their necessities and ways of living.

II. As in man and most other creatures, the eyes are situated in the head, because among other reasons, it is the most convenient place for their defence and security, being composed of hard bones, wherein are formed two large strong sinuses, or sockets, commonly called orbits, for the convenient lodgings of these tender organs, and securing them against external injuries: so in those creatures whose head, like their eyes and the rest of their body, is soft and without bones, nature has provided for this necessary and tender organ a wonderful kind of guard, by enduing the creature with a faculty of withdrawing his eyes into his head, and lodging them in the same safety within his body. We have a very beautiful example of this in snails, whose eyes are lodged in four horns, like stramentous spots, one at the end of each horn, which they can retract at pleasure, when in any danger. Hence it may be also observed, that the cornea in all animals that want eyelids, as fishes, exactly resembles in hardness the horn of a lanthorn; and therefore is not hurt by such particles as their eyes are commonly exposed to. And in the mole, because this animal lives under ground, it was necessary its eyes should be well guarded and defended against the many dangers and conveniences to which its manner of living exposes it: this is the reason why its eyes are so small, and that they are situated so far in the head, and covered so strongly with hair; and besides they can protrude and retract them at pleasure. See Comparative Anatomy.

III. The third and last reflection we shall make upon the external motion of our eyes, is what regards a problem which has very much perplexed both physicians and philosophers, viz. What is the cause of the uniform motion of both eyes?

In some creatures, such as fishes, birds, and among quadrupeds, the hare, cameleon, &c. the eyes are moved differently; the one towards one object, and the other towards another. But in man, sheep, oxen, and dogs, the motions are so uniform that they never fail to turn both towards the same place: hence in operations upon the eye that require it to be kept immoveable, sometimes it is necessary to tie up the sound eye with a compress, by which means the other is easier kept fixed and immoveable.

The final cause of this uniform motion is, 1. That the sight may be thence rendered more strong and perfect: for since each eye apart impresses the mind with an idea of the same object, the impression must be more strong and lively when both eyes concur; and that both may concur, it is necessary that they move uniformly; for though the retina, or immediate organ of vision is expanded upon the whole bottom of the eye, as far as the ligamentum ciliare, yet nothing is clearly and distinctly seen but what the eye is directed to. 2. A second advantage we reap from the uniform motion of the eyes, which is more considerable than the former, consists in our being thereby enabled to judge with more certainty of the distance of objects. See Optics.

There is yet another advantage, full as considerable as any of the former, that is thought to arise from the uniform motion of our eyes, and that is, the single appearance of objects seen with both our eyes; which, though at first view it does not appear probable, is true: for if in looking at an object you turn one of your eyes aside with your finger, and alter its direction, every thing will be seen double.

By the internal motions of the eye we understand those motions which only happen to some of its internal parts, such as the crystalline and iris; or to the whole eye when it changes its spherical figure, and becomes oblong or flat. The internal motions of our eyes are either such as respect the change of conformation that is necessary for seeing distinctly at different distances, or such as only respect the dilatation and contraction of the pupil.

That our eyes change their conformation, and accommodate themselves to the various distances of objects, will be evident to any person, who but reflects on the manner and most obvious phenomena of vision.

Authors are very much divided in their opinions with regard to the mechanism by which this change is introduced, as well as what parts it consists in: for some are of opinion that the whole globe changes its form, by being lengthened into an oblong figure when objects are near, and by becoming flat when they are removed to a greater distance; and others are of a quite contrary opinion.

With regard to the change of the crystalline, and the mechanism by which it is produced, some maintain, that according as objects are at different distances this humour becomes more or less convex, which does indeed very well account for distinct vision at different distances; since objects whose rays are admitted through a lens placed in the hole of a window-shutter, in a dark room, have their images always distinct, at whatever distance they may be from the window, provided the lens is of a convexity answerable to that distance.

Eye, in architecture, is used to signify any round window, made in a pediment, an attic, the reins of a vault, &c.

Eye *of a dome*, an aperture at the top of a dome, as that of the Pantheon at Rome, or of St. Paul's at London: it is usually covered with a lanthorn.

Eye *of the volute*, in architecture, is the centre of the volute, or that point in which the helix, or spiral of which it is formed, commences: or it is the little circle in the middle of the volute, in which are found the thirteen centres for describing the circumvolutions of it.

Eye, in agriculture and gardening, signifies a little bud or shoot inserted into a tree by way of graft.

Eyebright. See Euphrasia.

Eye *of the anchor*, on board a ship, the hole in which the ring of the anchor is put into the shank.

Eye *of the strap*, on board a ship, the ring or round which is left to the strap to which any block is seized.

Eye, in printing, is sometimes used for the thickness of the types; or, more properly, it signifies the graving in relievo on the top of the letter, otherwise called its face: the eye of the *e* is the small opening at the head of that letter, which distinguishes it from the *c*.

Eye-glass, in the microscope. See Microscope.

EYRE, or *eire*, in law, the court of itinerant justices. See Justices.

EZAN, in the Mahometan theology, a hymn containing the profession of their faith, which is repeated five times a day, to call the people to prayers.

EZEKIEL'S REED, or ROD, a measure of length mentioned by that prophet, and computed to be nearly equal to two English feet.

F.

F, the sixth letter of the alphabet. As a numeral it denotes 40, and with a dash over it thus $\overline{F}$, denotes 40,000: in music it stands for the bass-clef; and frequently for forte, as *ff* does for forte forte.

F, in medicine, stands for fiat, let it be done: thus F. S. A. stands for fiat secundum artem, let it be done according to art.

As an observation, F stands for filius, fellow, &c.: thus F. R. S. signifies Fellow of the Royal Society.

FA, in music, one of the syllables invented by Guido Aretine, to mark the fourth note of the modern scale, which rises thus, ut, re, mi, fa. Musicians distinguish two fa's, viz. the flat, marked with a *b*, or ♭, and the sharp or natural, marked thus ✱, and called biquadro.

FA FINTO, a feigned F, or a feint upon that note: this is the case of every note that has the mark ♭ before it; but more especially mi and si, or our E and B, and is what we commonly call the flat of any note.

FABA, the *bean*. See VICIA.

FABLE, *fabula*, a tale or feigned narration, designed either to instruct or amuse, disguised under the allegory of an action, &c. Fables were the first pieces of wit that made their appearance in the world, and have been still highly valued, not only in times of the greatest simplicity, but among the most polite ages of the world. Jotham's fable of the trees is the oldest that is extant, and as beautiful as any that has been made since. Nathan's fable of the poor man is next in antiquity, and had so good an effect as to convey instruction to the ear of a king. We find Æsop in the most distant ages of Greece; and in the early days of the Roman commonwealth, we read of a mutiny appeased by the fable of the belly and the members. There is scarcely a book in the whole compass of profane literature which contains a greater store of moral wisdom, frequently seasoned with no small share of wit, than Æsop's fables. It is injudiciously put into the hands of children who cannot understand it: its object is to instruct men.

FABLE is also used for the plot of an epic or dramatic poem; and is, according to Aristotle, the principal part, and the soul of a poem. See POETRY.

FABRIC-LANDS, those formerly given towards rebuilding or repairing of cathedrals and other churches; for anciently almost every body gave more or less, by his will, to the fabric of the parish-church where he dwelt.

FACE, or *facade*, in architecture, the front of a building, or the side which contains the chief entrance. Sometimes, however, it is used for whatever side presents to the street, garden, court, &c. or is opposite to the eye.

FACE *of a stone*, in masonry, that superficies of it which lies in the front of the work. The workmen generally choose to make one of those sides the face, which, when in the quarry, lay perpendicularly to the horizon, and consequently the breaking, not the cleaving way of the stone.

FACE, in fortification, an appellation given to several parts of a fortress, as the face of a bastion, &c. See FORTIFICATION.

FACE, in the military art, a word of command, intimating to turn about: thus, "Face to the right," is to turn upon the left heel a quarter-round to the right; and "Face to the left," is to turn upon the right heel a quarter-round to the left.

FACET, or *facette*, among jewellers, the name of the little faces or planes to be found in brilliant and rose diamonds.

FACTION, in antiquity, a name given to the different companies of combatants or racers in the circus. They were four, viz. the white, the red, the green, and the blue; to which Domitian added another of purple colour. They were so denominated from the colour of the liveries they wore, and were dedicated to the four seasons of the year, the green being consecrated to spring, the blue to winter, the red to summer, and the white to autumn. It appears from ancient inscriptions that each faction had its procurators and physician; and from history, that party rage ran so high among them, that in a dissension between two factions, in the time of Justinian, almost forty thousand men lost their lives in the quarrel. See Gibbon's Decline and Fall, &c.

FACTITIOUS, any thing made by art, in opposition to what is the produce of nature. Thus, factitious cinnabar is opposed to native cinnabar.

FACTOR, in commerce, is an agent or correspondent residing beyond the seas, or in some remote part, commissioned by merchants to buy or sell goods on their account, or assist them in carrying on their trade.

A factor receives from the merchants, his constituents, in lieu of wages, a commission or factorage, according to the usage of the place where he resides, or the business he transacts, this being various in different countries, and on the purchases and sales of different commodities. He ought to keep strictly to the tenor of his orders; as a deviation from them, even in the most minute particular, exposes him to make ample satisfaction for any loss that may accrue from his nonobservance of them; and it is very reasonable it should be so, as the distance of his situation renders him unable to judge of his principal's views and intention. When unlimited orders are given to factors, and they are left to sell or buy on the best conditions they can, whatever detriment occurs to their constituents, they are excused, as it is to be presumed they acted for the best, and were governed by the dictates of prudence. But a bare commission to sell is not sufficient authority for the factor to trust any person, wherefore he ought to receive the money on the delivery of the goods; and, by the general power, he may not trust beyond one, two, or three months, &c. the

usual time allowed in sales, otherwise he shall be answerable out of his own estate. If a factor sells on the usual trust to a person of good credit, who afterwards becomes insolvent, he is discharged; but not if the man's credit was bad at the time of sale. If a factor gives a man time for payment of money contracted on sale of his principal's goods, and, after that time is elapsed, sells him goods of his own for ready money, and the man becomes insolvent, the factor in equity ought to indemnify his principal, but he is not compellable by the common law. A factor should always be punctual in the advices of his transactions, in sales, purchases, freights, and more especially in draughts by exchange: he should never deviate from the orders he receives in the execution of a commission for purchasing goods, either in price, quality, or kind; and if, after goods are bought, he sends them to a different place from what he was directed to, they must remain for his own account, except the merchant, on advice of his proceedings, admits them according to his first intention. A factor that sells a commodity under the price he is ordered, shall be obliged to make good the difference: and if he purchases goods for another at a price limited, and afterwards they rise, and he fraudulently takes them for his own account, and sends them to another part, in order to secure an advantage that seemingly offers, he will, on proof, be obliged, by the custom of merchants, to satisfy his principal for damages. If a factor, in conformity with a merchant's orders, buys with his money, or on his credit, a commodity he shall be directed to purchase; and, without giving advice of the transaction, sells it again to profit, and appropriates to himself the advantage; the merchant shall recover it from him, and besides have him amerced for his fraud. When factors have obtained a profit for their principal, they must be cautious how they dispose of it; for if they act without commission they are responsible: and if a merchant remits goods to his factor, and about a month after draws a bill on him, the factor, having effects in his hands, accepts the bill, then the principal breaks, and the goods are seized in the factor's hands for the behalf of the creditors, it has been conceived the factor must answer the bill notwithstanding, and come in as a creditor for so much as he was obliged, by reason of his acceptance, to pay. A factor who enters into a charterparty with a master for freight, is obliged by the contract; but if he loads aboard generally, the principal and the lading are liable for the freight, and not the factor. If a factor, having money in his hands belonging to his principal, neglects to insure a ship and goods, according to order, if the ship miscarry, the factor, by the custom of merchants, shall make good the damage; and if he makes any composition with the insurers after insurance without orders so to do, he is answerable for the whole insurance.

As fidelity and diligence are expected from the factor, so the law requires the like from the principal; if, therefore, a merchant remits counterfeit jewels to his factor, who sells them as if true; if he receives loss or prejudice by imprisonment or other punishment, the principal shall not only make full satisfaction to the factor, but to the party who bought the jewels.

What is here said of factors, is meant of such as reside abroad to act for merchants; and may be applied to supercargoes, who go a voyage to dispose of a cargo, and afterwards return with another to their principals; but it is also the custom of the merchants of the highest credit throughout the world to act mutually in the capacity of factors for each other. The business so executed is called commission-business, and is generally desirable by all merchants, provided they have always effects in their hands, as a security for all the affairs which they transact for the account of others. And this class of traders of established reputation, have current as well as commission accounts, constantly between them; and draw on, remit to, and send commissions to each other only by the intercourse of letters, which, among men of honour, are as obligatory and authoritative as all the bonds and ties of law.

Factor, in multiplication, a name given to the multiplier and multiplicand, because they constitute the product.

FACTORAGE, called also commission, is the allowance given to factors by the merchant who employs them. A factor's commission in Britain, on most kinds of goods, is two and a half per cent.: on lead, and some other articles, two per cent.; in Italy, two and a half per cent.; in France, Holland, Spain, Portugal, Hamburgh, and Dantzic, two per cent.; in Turkey three per cent.; in North America five per cent. on sales, and five per cent. in returns; in the West Indies eight per cent. for commission and storage. In some places it is customary for the factors to insure the debts for an additional allowance, generally one and a half per cent. In that case they are accountable for the debt when the usual term of credit is expired. Factorage on goods is sometimes charged at a certain rate per cask, or other package, measure or weight, especially when the factor is only employed to receive or deliver them.

FACTORY is a place where a considerable number of factors reside, to negotiate for their masters or employers. The most considerable factories belonging to the British are those established in the East Indies, Portugal, Turkey, &c.

FACULÆ, in astronomy, certain bright and shining parts, which the modern astronomers have, by means of telescopes, observed upon or about the surface of the sun: they are but very seldom seen.

Hevelius assures us that, on July 20, 1634, he observed a facula, whose breadth was equal to a third part of the sun's diameter. He says too that the maculæ often change into faculæ, but these seldom or never into maculæ. And some authors even contend that all the maculæ degenerate into faculæ before they quite disappear. Many authors, after Kircher and Scheiner, have represented the sun's body full of bright, fiery spots, which they conceive to be a sort of volcanoes in the body of the sun; but Huygens, and others of the latest and best observers, finding that the best telescopes discover nothing of the matter, agree entirely to explode the phenomena of faculæ. All the foundation he could see for the notion of faculæ, he says, was, that in the darkish clouds which frequently surrounded the maculæ, there are sometimes seen little points or sparks brighter than the rest.

FACULTY, in law, a privilege granted to a person, by favour and indulgence, of doing what, by law, he ought not to do. For granting these privileges there is

a court under the archbishop of Canterbury, called the court of the faculties, the chief officer of which is styled master of the faculties, who has a power of granting dispensations in divers cases: as to marry without the bans being first published; to ordain a deacon under age; for a son to succeed his father in his benefice; a clerk to hold two or more livings, &c.

FACULTY, in the schools, a term applied to the different members of an university, divided according to the arts and sciences taught there: thus in most universities there are four faculties, viz. 1. Of arts, which include humanity and philosophy. 2. Of theology. 3. Of physic. And, 4. Of civil law. The degrees in the several faculties in our universities are those of bachelor, master, and doctor.

FACULTY OF ADVOCATES, a term applied to the college or society of advocates in Scotland, who plead in all actions before the court of sessions. They meet in the beginning of every year, and choose the annual officers of the society, viz. dean, treasurer, clerks, private and public examinators, and a curator of their library. The manner of admission into the faculty of associates is by a trial in the civil law, and Scotch law: the person desiring to be admitted having, upon petition, obtained a recommendation to the dean of the faculty, he gives a remit to the private examinators, who are nine in number, and who, after their election, having divided the body of the civil law into nine parts, each taking one, appoint a diet for examination: in this diet there must be at least seven present, each of whom examines the candidate; and the question being afterwards put, Qualified, yea or no? they give their opinion by balloting, upon which the candidate is either admitted by signing his petition, or remitted to his studies. After the private trial the dean of the faculty assigns the candidate a title of the civil law, for the subject of a thesis; which being distributed among the advocates, the faculty meet on a day appointed, when three at least of fifteen public examinators dispute against the thesis; and afterwards the faculty give their opinions by balloting, as in the private trial. If the candidate is found qualified, the dean assigns him a law for an harangue before the lords; which harangue being made, he is admitted a member of the faculty, upon paying the fees,taking the oaths to the government, and an oath to be faithful in his office.

FACULTY is also used to denote the powers of the human mind, viz. understanding, will, memory, and imagination.

FÆCES, in chemistry, the gross matter, or sediment, that settles at the bottom after distillation, fermentation, &c.

FÆCULA. See GLUTEN.

FAGARA, *iron wood*, a genus of the monogynia order, in the tetrandria class of plants, and in the natural method ranking under the 43d order, dumosæ. The calyx is quadrifid, the corolla tetrapetalous, and the capsule bivalved and monospermous. There are 10 species, all natives of the warm parts of America, rising with woody stems more than 20 feet high. They are propagated by seeds; but in England they must be kept continually in a stove.

FAGG, in the sea language, a term given to the end of those strands which do not go through the tops, when a cable or rope is closed.

FAGONIA, a genus of the monogynia order, in the decandria class of plants, and in the natural method ranking under the 14th order, gruinales. The calyx is pentaphyllous; the petals are five, and heart-shaped; the capsule is quinquelocular, ten-valved, with the cells monospermous. There are three species, herbaceous plants of Spain, Crete, and Arabia.

FAGRÆA, a genus of the class and order pentandria monogynia. The calyx is bell-shaped; corolla funnel-shaped; berry two-celled, fleshy, seeds globular; stigma peltate. There is one species, a shrub of Ceylon.

FAGUS, the *beech-tree*, a genus of the polyandria order, in the monœcia class of plants; and in the natural method ranking under the 50th order, amentaceæ. The male calyx is quinquefid, and campanulated: there is no corolla; the stamina are 12; the female calyx is quinquedentated; there is no corolla; there are three styles; the capsule (formerly the calyx) is muricated and quadrivalved; the seeds two in number. There are five species. The most remarkable are,

1. The sylvatica, or beech-tree, rises 60 or 70 feet high, and has a proportionable thickness, branching upward into a fine regular head, with oval serrated leaves, with flowers in globular catkins, succeeded by angular fruit called mast.

2. The castanea, or chesnut-tree, has a large upright trunk growing 40 or 50 feet high, branching regularly round into a fine spreading head, with large spear-shaped acutely serrated leaves, naked on the under side, having flowers in long amentums, succeeded by round prickly fruit, containing two or more nuts.

3. The pumila, dwarf chesnut-tree, or chinkapin, rises eight or ten feet high, with a branching shrubby stem, and oval spear-shaped and acutely serrated leaves, hoary on the under side.

The first species is very easily raised from the mast or seed. "For woods (says Evelyn) the beech must be governed as the oak; in nurseries as the ash: sowing the masts in autumn, or later, even after January, or rather nearer the spring, to preserve them from vermin, which are very great devourers of them. But they are likewise to be planted of young seedlings, to be drawn out of the places where the fruitful trees abound. Millar says, the season for sowing the masts " is any time from October to February, only observing to secure the seeds from vermin when early sowed; which, if carefully done, the sooner they are sown the better after they are fully ripe." Hambury orders a sufficient quantity of masts to be gathered about the middle of September, when they begin to fall: these are to be "spread upon a mat in an airy place six days to dry; and after that you may either proceed to sow them immediately, or you may put them up in bags in order to sow them nearer the spring: as they will keep very well, and there will be less danger of having them destroyed by mice or other vermin, by which kinds of animals they are greatly relished." They must be sown in beds properly prepared, about an inch deep. In the first spring many of the young plants will appear, whilst others will not come up till the spring following. Having stood two years in the seminary,

they should be removed to the nursery, where they may remain till wanted.

The propagation of the second species is also chiefly from seeds. Evelyn says, "Let the nuts be first spread to sweat, then cover them in sand; a month being past, plunge them in water, and reject the swimmers; being dried for 30 days more, sand them again, and expose them to the water-ordeal as before. Being thus treated until the beginning of spring or in November, set them as you would beans; and, as some practise it, drenched for a night or more in new milk; but with half this preparation they need only to be put into the holes with the point upwards, as you plant tulips. If you design to set them in winter or autumn, I counsel you to inter them in their husks, which being every way armed, are a good protection against the mouse, and a providential integument."—"Being come up, they thrive best unremoved, making a great stand for at least two years upon every transplanting; yet if you must alter their station, let it be done about November." Millar cautions us against purchasing foreign nuts that have been kiln-dried, which (he says) is generally done to prevent their sprouting in their passage; therefore he adds, "If they cannot be procured fresh from the tree, it will be much better to use those of the growth of England, which are full as good to sow for timber or beauty as any of the foreign nuts, though their fruit is much smaller." He also recommends preserving them in sand, and proving them in water. In setting these seeds or nuts, he says, "The best way is to make a drill with a hoe (as is commonly practised for kidney-beans), about four inches deep, in which you should place the nuts, at about four inches distance, with their eye uppermost; then draw the earth over them with a rake, and make a second drill at about a foot distance from the former, proceeding as before, allowing three or four rows in each bed. In April (he does not mention the time of sowing) these nuts will appear above ground; you must therefore observe to keep them clear from weeds, especially while young: in these beds they may remain for two years, when you should remove them into a nursery at a wider distance. The best time for transplanting these trees is either in October, or the end of February, but October is the best season: the distance these should have in the nursery is three feet row from row, and one foot in the rows. If these trees have a downright tap-root, it should be cut off, especially if they are intended to be removed again: this will occasion their putting out lateral shoots, and render them less subject to miscarry when they are removed for good. The time generally allowed them in the nursery is three or four years, according to their growth; but the younger they are transplanted the better they will succeed. Young trees of this sort are apt to have crooked stems; but when they are transplanted out, and have room to grow, as they increase in bulk they will grow more upright, and their stems will become straight, as I have frequently observed where there have been great plantations." Hanbury follows Millar almost literally, except that he mentions February as the time of sowing; and recommends that the young plants, a year after they have been planted in the nursery, be cut down to within an inch of the ground; which (he says) "will cause them to shoot vigorously with one strong and straight stem." There is one material objection against sowing chesnuts in drills, which are well known to serve as guides or conductors to the field-mouse, who will run from one end to the other of a drill without letting a single nut escape her: we rather recommend setting them with a dibble, either promiscuously or quincunx, at about six inches distance. Evelyn says, that coppices of chesnuts may be thickened by lowering the tender young shoots; but adds, that "such as spring from the nuts and marrons are best of all." There is a striped-leaved variegation which is continued by budding; and the French are said to graft chesnuts for their fruit; but Millar says, such grafted trees are unfit for timber. The chesnut will thrive upon almost any soil which lies out of the water's way; but dislikes wet moory land.

The method of propagating the dwarf-chesnut is from seeds. These should be planted in drills, in a moist bed of rich garden-mould. If the seeds are good they will come up pretty soon in the spring. After they appear they will require no trouble except keeping them clean from weeds, and watering them in dry weather. They may stand in the seed-bed two years, and be afterwards planted in the nursery ground, at a foot asunder, and two feet distance in the rows; and here when they are got strong plants they will be fit for any purpose.

In stateliness and grandeur of outline the beech excels the oak. Its foliage is peculiarly soft and pleasing to the eye; its branches are numerous and spreading; and its stem grows to a great size. The bark of the beech is remarkably smooth, and of a silvery cast: this, added to the splendour and smoothness of its foliage, gives a striking neatness and delicacy to its general appearance. The beech therefore, standing singly, and suffered to form its own natural head, is highly ornamental: and its leaves varying their hue as the autumn approaches, renders it in this point of view still more desirable. In respect of actual use the beech follows next to the oak and the ash: it is almost as necessary to the cabinet-maker and turner as the oak is to the shipbuilder, or the ash to the plough and cart-wright. Evelyn nevertheless condemns it in pointed and general terms; because "where it lies dry, or wet and dry, it is exceedingly obnoxious to the worm." He adds, however, "but being put ten days in water it will exceedingly resist the worm." The natural soil and situation of the beech are upon dry, chalky, or limestone heights: it grows to a great size upon the hills of Surry and Kent; as also upon the declivities of the Cotswold and Stroudwater hills of Gloucestershire, and flourishes exceedingly upon the bleak banks of the Wye, in Hereford and Monmouth shires; where it is much used in making charcoal. In situations like those, and where it is not already prevalent, the beech, whether as a timber-tree or as an underwood, is an object worthy the planter's attention.

The mast, or seeds, yield a good oil for lamps; and are a very agreeable food to spuirrels, mice, and swine. The fat of swine fed with them, however, is soft, and boils away, unless hardened by some other food. The leaves gathered in autumn, before they are much injured by the frosts, make much better mattrasses than straw or chaff, and last for seven or eight years. The nuts when eaten by the human species, occasion giddiness

and headache; but when well dried and powdered they make wholesome bread. They are sometimes roasted, and substituted for coffee. The poor people in Silesia use the expressed oil instead of butter.

The chesnut-tree sometimes grows to an immense size. The largest in the known world are those which grow upon mount Ætna in Sicily. At Tortworth in Gloucestershire is a chesnut-tree 52 feet round. It is proved to have stood there ever since the year 1150, and was then so remarkable that it was called the great chesnut of Tortworth. It fixes the boundary of the manor, and is probably near 1000 years old. As an ornamental, the chesnut, though unequal to the oak and beech, has a degree of grandeur belonging to it which recommends it strongly to the planter's attention. Its uses have been highly extolled, and it may deserve a considerable share of the praise which has been given it. As a substitute for the oak it is preferable to the elm for door-jambs, window-frames, and some other purposes of the house-carpenter: it is nearly equal to oak itself; but it is very apt to be shaky, and there is a deceitful brittleness in it which renders it unsafe to be used as beams, or in any other situation where an uncertain load is required to be borne. It is universally allowed to be excellant for liquor-casks; as not being liable to shrink, nor to change the colour of the liquor it contains: it is also strongly recommended as an underwood for hop-poles, stakes, &c. Its fruit too is valuable, not only for swine and deer, but as human food: bread is said to have been made of it. Upon the whole, the chesnut, whether in the light of ornament or use, is undoubtedly an object of the planter's notice.

FAILLIS, in heraldry, a French term denoting some failure or fraction in an ordinary, as if it was broken, or a splinter taken from it.

FAIR, a greater kind of market, granted to a town, by privilege, for the more speedy and commodious providing of such things as the place stands in need of.

It is incident to a fair, that persons shall be free from being arrested in it for any other debt or contract than what was contracted in the same, or at least promised to be paid there. Also proclamation is to be made, how long they are to continue; and no person shall sell any goods after the time of the fair is ended, on forfeiture of double the value, one fourth to the prosecutor, and the rest to the king. There is a toll usually paid in fairs, on the sale of things, and for stallage, picage, &c.

Fairs abroad are either free, or charged with toll and imposition. The privileges of free fairs consist chiefly, first, in that all traders, &c. whether natives or foreigners, are allowed to enter the kingdom, and are under the royal protection, exempt from duties, impositions, tolls, &c. Secondly, that merchants, in going or returning, cannot be molested or arrested, or their goods stopped. They are established by letters-patent from the prince. Fairs, particularly free fairs, make a very considerable article in the commerce of Europe, especially that of the Mediteranean, and inland parts of Germany, &c.

The principal British fairs are, 1. Sturbridge-fair, near Cambridge, by far the greatest in Britain, and perhaps in the world. 2. Bristol has two fairs, very near as great as that of Sturbridge. 3. Exeter. 4. West Chester. 5. Edinburgh. 6. Wheyhill; and, 7. Burford-fair, both for sheep. 8. Pancras-fair, in Staffordshire, for saddle-horses. 2. Bartholomew fair, at London, for lean and Welsh black cattle. 10. St. Faith's, in Norfolk, for Scotch runts. 11. Yarmouth fishing-fair for herrings, the only fishing-fair in Great Britain. 12. Ipswich butter-fair. 13. Woodborough-hill, in Dorsetshire, for west-country manufactures, as kerseys, druggets, &c. 14. Two cheese-fairs at Chipping Norton: with innumerable other fairs, besides weekly markets, for all sorts of goods, as well our own as of foreign growth.

Among the principal free fairs in France were those of St. Germains, Lyons, Rheims, Chartres, Rouen, Bourdeaux, Troyes, Bayonne, Dieppe, &c.

The most noted fairs in Germany are those of Francfort, Leipsic, and Nurenburg; not only on account of the great trade, but the vast concourse of princes of the empire, nobility, and people, who come to them from all parts of Germany to partake of the diversions.

FAIRY-CIRCLE, or *ring*, a phenomenon frequent in the fields, &c. supposed by the vulgar to be traced by the fairies in their dances: there are two kinds of it; one of about seven yards in diameter, containing a round bare path, a foot broad, with green grass in the middle of it. The other is of different bigness, encompassed with a circumference of grass greener and fresher than that in the middle. Mess. Jessop and Walker, in the Philosophical Transact. ascribed them to lightning: we have however examined them ourselves, and are convinced they are produced by a kind of fungus which breaks and pulverizes the soil; why this vegetable should put forth its offsets in this kind of circular direction we cannot rightly account. The circles however are seldom complete, and often very irregular.

FAKE, among sailors, signifies one round or circle of a cable or hawser, coiled up out of the way.

FALCATED, something in the form of a sickle: thus the moon is said to be falcated when she appears horned.

FALCO, in ornithology, a genus belonging to the order of accipitres, the characters of which are these: the beak is crooked, and furnished with wax at the base; the head is thick-set with feathers, and the tongue is cloven. The eagle, kite, and hawk, form this genus. There are 32 species, of which the following are the most remarkable.

1. The leucocephalus, bald, or white-headed eagle of Catesby, is ash-coloured, with head and tail white; the iris of the eye is white over which is a prominence covered with a yellow skin; the bill and the cere or wax are yellow, as are likewise the legs and feet; and talons are black. Though it is an eagle of small size, it weighs nine pounds, is strong and full of spirit, preying on lambs, pigs, and fawns. They always make their nests near the sea or great rivers, and usually upon old dead pine or cypress trees, continuing to build annually on the same tree till it falls. Though he is so formidable to all birds, yet he suffers them to build near his royal nest without molestation; particularly the fishing-hawk, herons, &c. which all build on high trees, and in some places are so near one another that they appear like a rookery. The nests are very large and very fetid, owing to the relics of their prey. Lawson says they breed very often, laying again under their callow young, whose warmth hatches the eggs. In Bering's isle they make their nests on the

cliffs near six feet wide and one thick; and lay two eggs in the beginning of July. This species inhabits both Europe and America; but is more common in the latter. Besides flesh, it feeds also on fish. This, however, it does not procure for itself; but sitting in a convenient spot, watches the diving of the fishing-hawk into the water after a fish; which the moment it has seized, the bald eagle follows close after, when the hawk is glad to escape by dropping the fish from his bill; and such is the dexterity of the former, that it often seizes the prey before it can fall to the ground. Catesby says the male and female are much alike.

2. The ossifragus, sea-eagle, or osprey with yellow wax, and half-feathered legs: it is about the size of a peacock; the feathers are white at the base, iron-coloured in the middle, and black at the points; and the legs are yellow. It is found in several parts of Great Britain and Ireland. Mr. Willughby tells us, that there was an eyrie of them in Whinfield-park, Westmoreland; and the bird soaring in the air with a cat in its talons (which Barlow drew from the very fact which he saw in Scotland) is of this kind. The cat's resistance brought both animals to the ground, when Barlow took them up; and afterwards caused the fact to be engraved in the 36th plate of his collection of prints. Turner says, that in his days this bird was too well known in England; for it made horrible destruction among the fish. All authors indeed agree, that it feeds principally on fish, which it takes as they are swimming near the surface, by darting down upon them; not by diving or swimming, as some authors have pretended, who furnish it for that purpose with one webbed foot to swim with, and another divided foot to take its prey. Martin, speaking of what he calls the great eagles of the Western isles, says, that they fasten their talons in the back of the fish, commonly of salmon, which are often above the water, or very near the surface. Those of Greenland will even take a young seal out of the water.

3. The chrysaëtos, or golden eagle (See Pl. LV. Nat. Hist. fig. 191) weighs about twelve pounds, and is in length about three feet, the wings when extended measuring about seven feet four inches. The sight and sense of smelling are very acute: the head and neck are clothed with narrow sharp-pointed feathers, of a deep brown colour bordered with tawny; the hind part of the head in particular is of a bright rust-colour. These birds are very destructive to fawns, lambs, kids, and all kinds of game; particularly in the breeding season, when they bring a vast quantity of prey to their young. Smith, in his History of Kerry, relates that a poor man in that country got a comfortable subsistence for his family, during a summer of famine, out of an eagle's nest, by robbing the eagles of the food which the old one brought; whose attendance he protracted beyond the natural time, by clipping the wings and retarding the flight of the former. It is very unsafe to leave infants in places where eagles frequent, there being instances in Scotland of two being carried off by them; but, fortunately, the theft was discovered in time, and the children were restored unhurt out of the eagle's nests. In order to extirpate these pernicious birds, there is a law in the Orkney isles, which intitles every person that kills an eagle to a hen out of every house in the parish where it was killed. Eagles seem to give the preference to the carcases of dogs and cats. People who make it their business to kill those birds, lay one or other of these carcases by way of bait; and then conceal themselves within gunshot. They fire the instant the eagle alights; for she, that moment, looks about before she begins to prey. Yet, quick as her sight may be, her sense of hearing seems still more exquisite. If hooded crows or ravens happen to be nearer the carrion, and resort to it first, and give a single croak, the eagle is certain instantly to repair to the spot.

Eagles are remarkable for their longevity, and for their power of sustaining a long abstinence from food. Mr. Keysler relates, that an eagle died at Vienna after a confinement of 104 years. This pre-eminent length of days probably gave occasion to the saying of the Psalmist. "Thy youth is renewed like the eagle's." One of this species, which was nine years in the possession of Owen Holland, esq. of Conway, lived 32 years with the gentleman who made him a present of it; but what its age was when the latter received it from Ireland is unknown. The same bird also furnishes us with a proof of the truth of the other remark; having once, through the neglect of servants, endured hunger for 21 days without any sustenance whatever.

4. The fulvus, or white-tailed eagle of Edwards, has the whole plumage of a dusky-brown: the breast marked with triangular spots of white, but which are wanting in the British kind: the tail is white, tipt with black; but in young birds dusky, blotched with white: the legs are covered to the toes with soft rust-coloured feathers. These birds inhabit Hudson's-bay and northern Europe as far as Drontheim. They are found on the highest rocks of the Uralian chain, where it is not covered with wood; but are most frequent on the Siberian, where they make their nests on the loftiest rocks. They are rather inferior in size to the sea-eagle; but are generous, spirited, and docile. The Independant Tartars train them for the chase of hares, foxes, antelopes, and even wolves. This practice is of considerable antiquity; for Marco Polo, the great traveller of 1269, observed and admired the diversion of the great cham of Tartary, who had several eagles which were applied to the purposes we have here described. The Tartars also esteem the feathers of the tail as the best they have for pluming their arrows. This species is frequent in Scotland; where it is called the black eagle, from the dark colour of its plumage. It is very destructive to deer, which it will seize between the horns; and by incessantly beating it about the eyes with its wings, soon makes a prey of the harassed animal. The eagles in the isle of Rum have nearly extirpated the stags that used to abound there. They generally build in cliffs or rocks near the deer-forests; and make great havock not only among them, but also among the white hares and ptarmigans. Mr. Willughby gives the following curious account of the nest of this species. "In the year of our Lord 1668, in the woodlands near the river Darwent, in the peak of Derbyshire, was found an eagle's nest made of great sticks, resting one end on the edge of a rock, the other on two birch-trees; upon which was a layer of rushes, and over them a layer of heath, and upon the heath rushes again; upon which lay one young one and an addled egg; and by them a lamb, a hare, and three heathpoults. The nest

was about two yards square, and had no hollow in it. The young eagle was as black as a hobby, of the shape of a gos-hawk, almost of the weight of a goose, rough-footed, or feathered down to the foot: having a white ring about the tail.

5. the cyaneus, or hen-harrier, with white wax, yellow legs, a whitish-blue body, and a white ring round the eyes and throat. It is the blue hawk of Edwards, and is a native of Europe and Africa. These birds are extremely destructive to young poultry and to the feathered game: they fly near the ground, skimming the surface in search of prey. They breed on the ground, and are never observed to settle on trees.

6. The albicilla, or cinereous eagle, is inferior in size to the golden eagle; the head and neck are of a pale ash-colour; the body and wings cinereous, clouded with brown; the quill feathers very dark; the tail white; the legs feathered but little below the knees, and of a very bright yellow. The male is of a darker colour than the female. The bill of this species is rather straighter than is usual in the eagle, which seems to have induced Linnæus to place it among the vultures. But Mr. Pennant observes, that it can have no title to be ranked with that genus, the characteristical mark of which is, that the head and neck are either quite bare, or only covered with down; whereas this bird is wholly feathered. This species is in size equal to the black eagle, and inhabits Europe as high as Iceland and Lapmark. It is common in Greenland, but does not extend to America; or, according to Mr. Pennant, if it does, it varies into the white-headed eagle, to which it has great affinity particularly on its feeding much on fish: the Danes therefore call it fiskéorn. It is common in the south of Russia, and about the Volga, as far as trees will grow; but it is very scarce in Siberia. It inhabits Greenland the whole year, sitting on the rocks with flagging wing, and flies slowly. It makes its nest on the lofty cliffs, with twigs, lining the middle with mosses and feathers; lays two eggs; and sits in the latter part of May or beginning of June. These birds prey on young seals, which they seize as they are floating on the water; but frequently, by fixing their talons in an old one, they are overmatched, and drawn down to the bottom, screaming horribly. They feed also on fish, especially the lumpfish, and a sort of trout; on ptarmigans, auks, and eider ducks. They sit on the top of rocks, attentive to the motion of the diving birds, and with quick eyes observe their course by the bubbles which rise to the surface of the water, and catch the fowls as they rise for breath. The Greenlanders use their skins for clothing next to their bodies; eat the flesh; and keep the bill and feet for amulets. They kill them with the bow; or take them in nets placed in the snow properly baited; or tempt them by the fat of seals, which the eagles eat to an excess which occasions such a torpidity as to make them an easy prey. They are common in Scotland and the Orkneys, where they feed on fish, as well as on land-animals.

7. The maculatus, or the crying eagle, with a dusky bill and yellow cere; the colour of the plumage is a ferruginous brown; the coverts of the wings and scapulars are elegantly varied with oval white spots; the primaries dusky, the ends of the greater, white; the breast and belly are of a deeper colour than the rest of the plumage, streaked downwards with dull yellow; the tail is dark brown, tipt with dirty white; the legs are feathered to the feet, which are yellow. The length of the bird is two feet. This species is found in many parts of Europe, but not in Scandinavia: is frequent in Russia and Siberia; and extends even to Kamschatka. It is less generous and spirited than other eagles, and is perpetually making a plaintive noise; from which it was styled by the ancients planga et clanga; and anataria, from its preying on ducks, which Pliny describes with great elegance. The Arabs used to train it for the chase: but its quarry was cranes and other birds, the more generous eagle being flown at antelopes and other quadrupeds. This species was itself an object of diversion, and made the game of even so small a bird as the sparrowhawk; which would pursue it with great eagerness, soar above, and then fall on it, and fastening with its talons, keep beating it about the head with its wings, till they both fell together to the ground. This sir John Chardin has seen practised about Tauris.

8. The milvus, or kite, is a native of Europe, Asia, and Africa. This species generally breeds in large forests or woody mountainous countries. Its nest is composed of sticks, lined with several odd materials, such as rags, bits of flannel, rope, and paper. It lays two, or at most three, eggs; which, like other birds of prey, are much rounded and blunt at the smaller end. They are white spotted with dirty yellow. Its motion in the air distinguishes it from all other birds, being so smooth and even that it is scarcely perceptible. Sometimes it will remain quite motionless for a considerable space; at others glide through the sky without the least apparent action of its wings; thence deriving the old name of glead, or glede, from the Saxon glida. They inhabit the north of Europe, as high as Jalsberg, in the very south of Norway; but do not extend farther. They quit Sweden in flocks at the approach of winter, and return in spring. Some of them winter about Astrakan, in lat. 46, 30: but the far greater part are supposed to retire into Egypt, being seen in September passing by Constantinople in their way from the north; and again in April returning to Europe, to shun the great heats of the East. They are observed in vast numbers about Cairo, where they are extremely tame, and feed even on dates, probably for want of other food. They also breed there; so that, contrary to the nature of other rapacious birds, they increase and multiply twice in the year; once in the mild winters of Egypt, and a second time in the summers of the north. It makes its appearance in Greece in the spring; and in the early ages, says Aristophanes, "it governed that country; and men fell on their knees when they were first blessed with the sight of it, because it announced the flight of winter, and told them to begin to shear their vernal fleeces." In Britain they are found the whole year. Lord Bacon observes, that when kites fly high, it portends fair and dry weather. See Plate LV. Nat. Hist. fig. 197.

9. The gentilis, or gentil falcon, inhabits the north of Scotland, and was in high esteem as a bold and spirited bird in the days of falconry. It makes its nest in rocks: it is larger than the gos-hawk; the head of a light rust-colour, with oblong black spots; the whole

under side from chin to tail white, tinged with yellow; the back of a brown colour; the tail barred with four or five bars of black, and as many of ash-colour; the very tips of all the tail feathers white.

10. The subbuteo, or hobby, was used like the kestrel in the humbler kind of falconry; particularly in what was called daring of larks: the hawk was cast off; the larks, aware of their most inveterate enemy, were fixed to the ground for fear; by which means they became a ready prey to the fowler, who drew a net over them. The back of the bird is brown: the nape of the neck white: and the belly pale, with oblong brown spots. It is a bird of passage; but breeds in Britain, and migrates in October.

11. The buteo, or buzzard, is the most common of the hawk kind in England. It breeds in large woods; and usually builds on an old crow's nest, which it enlarges, and lines with wool and other soft materials. It lays two or three eggs, which are sometimes perfectly white, sometimes spotted with yellow. The cock-buzzard will hatch and bring up the young if the hen is killed. The young keep company with the old ones for some little time after they quit the nest; which is not usual with other birds of prey, who always drive away their brood as soon as they can fly. The buzzard is very sluggish and inactive, and is much less in motion than any other hawks; remaining perched on the same bough for the greatest part of the day, and dwelling at most times near the same place. It feeds on birds, rabbits, moles, and mice; it will also eat frogs, earthworms, and insects. This bird is subject to some variety in its colour. Some have the breast and belly of a brown colour, and are only marked across the craw with a large white crescent; but usually the breast is of a yellowish white, spotted with oblong rust-coloured spots, pointing downwards, the back of the head, neck, and coverts of the wings, are of a deep brown, edged with a pale rust-colour: the middle of the back covered only with thick white down. The tail is barred with black and ash-colour, and sometimes ferruginous.

12. The tinnunculus, or kestrel, breeds in the hollows of trees, in the holes of high rocks, towers, and ruined buildings. It feeds on field-mice, small birds, and insects: which it will discover at a great distance. This is the hawk that we so frequently see in the air as fixed in one place; and, as it were, fanning with its wings; at which time it is watching for its prey. When falconry was in use in Great Britain, this bird was trained for catching of small birds and young partridges. It is easily distinguished from all other hawks by its colours. The crown of the head and the greater part of the tail are of a light grey; the back and coverts of the wing of a brick-red, elegantly spotted with black; the whole under side of the bird of a pale rust-colour spotted with black.

13. The sufflator, with yellowish wax and legs; the body is of a brownish-white colour; and the covers of the eyes are bony. He has a fleshy lobe between the nostrils; which, when angry or terrified, he inflates till his head becomes as big as his whole body. He is a native of Surinam.

14. The cachinnans, or laughing hawk, has yellowish legs and wax, and white eyebrows; the body is variegated with brown and white: and has a black ring round the top of the head. It makes a laughing kind of noise when it observes any person, and is a native of America.

15. The Columbarius, or pigeon-hawk of Catesby, weighs about six ounces. The bill is black at the point, and whitish at the base: the iris of the eye is yellow; the base of the upper mandible is covered with a yellow cere of wax: all the upper part of the body, wings, and tail, are brown. The anterior vanes of the quill-feathers have large red spots. The tail is marked with large regular transverse white lines; the throat, breast, and belly, are white, mixed with brown; the small feathers that cover the thighs reach within half an inch of the feet, and are white, with a tincture of red, beset with long spots of brown; the legs and feet are yellow. It inhabits America, from Hudson's-bay as low as South Carolina. In the last it attains to a larger size. In Hudson's-bay it appears in May on the banks of the river Severn, breeds, and retires south in autumn. It feeds on small birds; and, on the approach of any person, flies in circles, and makes a great shrieking. It forms its nest in a rock, or some hollow tree, with sticks and grass; and lines it with feathers; and lays from two to four eggs, white spotted with red. In Carolina it preys on pigeons, and the young of the wild turkeys.

16. The furcatus, or swallow-tailed hawk, has a black bill, less hooked than usual with rapacious birds: the eyes are large and black, and with a red iris: the head, neck, breast, and belly, are white; the upper part of the back and wings a dark purple; but more dusky towards the lower parts, with a tincture of green. The wings are long in proportion to the body, and when extended, measure four feet. The tail is dark purple mixed with green, and remarkably forked. This most elegant species inhabits the southern parts of North America only during summer. Like swallows, they feed chiefly flying; for they are much on wing, and prey on various sorts of insects. They also feed on lizards and serpents; and will kill the largest of the regions it frequents with the utmost ease. They quit North America before winter, and are supposed to retreat to Peru.

17. Haliætus, the fishing-hawk of Catesby, sometimes called the osprey, weighs 3 pounds and a quarter; it measures, from one end of the wing to the other, five feet and a half. The bill is black, with a blue cere or wax; the iris of the eye is yellow, and the crown of the head brown, with a mixture of white feathers; from each eye, backwards, runs a brown stripe: the back, wings, and tail, are of a dark brown; the throat, neck, and belly, white; the legs and feet are rough and scaly, and of a pale blue colour; the talons are black, and nearly of an equal size: the feathers of the thigh are short, and adhere close to them, contrary to others of the hawk kind, which nature seems to have designed for the more easily penetrating the water. Notwithstanding this bird is so persecuted by the bald eagle, yet it always keeps near its haunts. It is a species of vast quickness of sight; and will see a fish near the surface from a great distance, descend with prodigious rapidity, and carry the prey with an exulting scream high into the air. The eagle hears the note; and instantly attacks the fishing-

hawk: who drops the fish, which the former catches before it can reach the ground or water. The lower parts of the rivers and creeks near the sea, in America, abound with these eagles and hawks, where such diverting contests are often seen. It sometimes happens that this bird perishes in taking its prey, for if it chances to fix its talons in an overgrown fish it is drawn under water before it can disengage itself, and is drowned. See Plate LV. Nat. Hist. fig. 194.

18. The gyrfalco, or Iceland falcon, has a strong bill, much hooked, the upper mandible sharply angulated on the lower edges, with a bluish wax: the head is of a very pale rust-colour, streaked downwards with dusky lines: the neck, breast, and belly, are white, marked with cordated spots; the thighs white, crossed with short bars of deep brown: the back and coverts of the wings are dusky, spotted, and edged with white; the exterior webs of the primaries dusky mottled with reddish-white, the inner barred with white; the feathers of the tail are crossed with 14 or more narrow bars of dusky and white, the dusky bars regularly opposing those of white: the wings, when closed, reach almost to the end of the train: the legs are strong and yellow. The length of the wing, from the pinion to the tip, is sixteen inches. This species is an inhabitant of Iceland, and is the most esteemed of any for the sport of falconry.

19. The fuscus, or Greenland eagle, has dusky irides; lead-coloured wax and feet; brown crown, marked with irregular oblong white spots; whitish forehead; blackish cheeks; the hind part of the head and throat white; breast and belly of a yellowish white, striped downwards with dusky streaks; the back dusky, tinged with blue, the ends of the feathers lightest, and sprinkled over with a few white spots, especially towards the rump; the wings of the same colours, variegated beneath with white and black; the upper part of the tail dusky, crossed very faintly with paler bars, the under side whitish. It inhabits all parts of Greenland, from the remotest hills to those which impend over the sea. They are even seen on the islands of ice remote from the shore. They retire in the breeding-season to the farthest part of the country, and return in autumn with their young. They breed in the same manner as the cinereous eagle, but in more distant places; and lay from three to five eggs. The tail of the young is black, with great brown spots on the exterior webs. They prey on ptarmigans, auks, and all the small birds of the country. They have frequent disputes with the raven, but seldom come off victors; for the raven will, on being attacked, fling itself on its back; and either by defending itself with its claws, or by calling, with its croaking, numbers of others to its help, oblige the falcon to retire. The Greenlanders use the skin, among others, for their inner garments; the wings for brushes; the feet for amulets; but seldom eat the flesh, unless compelled by hunger.

20. The candicans, or white gyrfalcon of Pennant, has the wax and bill bluish, the latter greatly hooked; the eye dark-blue; the throat of a pure white; the whole body, wings, and tail, of the same colour, most elegantly marked with dusky bars, lines, or spots, leaving the white the far prevailing colour. There are instances, but rare, of its being found entirely white. In some, the whole tail is crossed by remote bars of black or brown; in others, they appear only very faintly on the middle feathers: the feathers of the thighs are very long and unspotted; the legs strong, and of a light blue. Its weight is 45 ounces troy; length near two feet, extent four feet two. This species has the same manners and haunts with the former. It is very frequent in Iceland; is found in Lapmark and Norway, and rarely in the Orkneys and North Britain. In Asia, it dwells in the highest points of the Uralian and other Siberian mountains, and dares the coldest climates throughout the year. It is kept in the latitude of Petersburgh, uninjured in the open air during the severest winters. This species is pre-eminent in courage as well as beauty, and is the terror of the other hawks. It was flown at all kinds of fowl, how great soever they were: but its chief game used to be herons and cranes.

The last three species are in high esteem for sport. They are reserved for the kings of Denmark; who send their falconer with two attendants annually into Iceland to purchase them. They were caught by the natives, a certain number of whom in every district are licensed for that purpose. The Iceland falcons will last ten or twelve years; whereas those of Norway, and other countries, seldom are fit for sport after two or three years. Yet the Norwegian hawks were in old times in great repute in this kingdom, and even thought bribes worthy of a king.

21. The apivorus, with black wax, yellow legs half-naked, the head of an ash-colour, and having an ash-coloured stripe on the tail, which is white at the end. It is the honey-buzzard of Ray, and had that name from the combs of bees or wasps being found in its nest. It is a native of Europe, and feeds on mice, lizards, frogs, bees, &c. It runs very swiftly, like a hen.

22. The æruginosus, or moor-buzzard, with greenish wax, a greyish body, the top of the head, nape of the neck, and legs, yellowish; it is a native of Europe, and frequents moors, marshy places, and heaths: it never soars like other hawks; but commonly sits on the ground, or on small bushes. It makes its nest in the midst of a tuft of grass, or rushes. It is a very fierce and voracious bird; and is a great destroyer of rabbits, young wild ducks, and other water-fowl. It also preys, like the fishing-hawk, on fish.

23. The palumbarius, with black wax edged with yellow, yellow legs, a brown body, the prime feathers of the tail marked with pale streaks, and the eyebrows white. It is the gos-hawk of Ray; and was formerly in high esteem among falconers, being flown at cranes, geese, pheasants, and partridges. It breeds in Scotland, and builds its nest in trees. It is destructive to game, and dashes through the woods after its quarry with vast impetuosity; but if it cannot catch the object of its pursuit almost immediately, desists, and perches on a bough till some new game presents itself. This species is common in Muscovy and Siberia. They extend to the river Amur; and are used by the emperor of China in his sporting progresses, attended by his grand falconer, and 1000 of the subordinate. Every bird has a silver plate fastened to its foot, with the name of the falconer who has the charge of it; that, in case it should be lost, it might be brought to the proper person: but if he could not be found, the bird is delivered to another officer,

called the guardian of lost birds; who keeps it till it is demanded by the falconer to whom it belonged. That this great officer may the more readily be found among the army hunters who attend the emperor, he erects a standard in the most conspicuous place.

24. The nisus, or sparrowhawk, with green wax, yellow legs, a white belly undulated with grey, and the tail marked with blackish belts. This is the most pernicious hawk we have, and makes great havock among pigeons as well as partridges. It builds in hollow trees, in old nests of crows, large ruins, and high rocks: it lays four white eggs, encircled near the blunter end with red specks.

25. The minutus, with white wax, yellow legs, and the body white underneath. It is the least hawk of Brisson, being about the size of a thrush: and is found on the island of Melita.

Besides these we may mention the litho-falco, or stone falcon, which inhabits many parts of Europe, and is about a foot long; the bill blueish-ash; irids yellow; two middle tail-feathers uniform, the rest barred with brown: the gallicus or French eagle, so called from its being found chiefly in France, about two feet long, feeds on rats, mice, and frogs; it builds its nest mostly on the ground; the irids yellow; tail-feathers white with brown transverse stripes, brown at the tips and edges; claws grey: the lacer inhabits Europe, Tartary in Asia, and many parts of North America; it is two feet long, patient of cold; used in hunting the white heron: the head pale brown; wing-coverts and primary quill feathers with transverse white lines; tail brown, with oval transverse red spots on the sides; legs feathered to the toes: and the magnirostris, or great billed falcon, found in Cayenne a little larger than the sparrowhawk; legs shorter; bill longer, thicker, black; irids orange; feathers above and on the breast brown edged with rusty; claws black. See Plate LV. Nat. Hist. figs. 192, 193, 195, and 196.

There are some other species distinguished by ornithologists. Among these are two described by Mr. Bruce; of which one deserves particular notice, as being not only the largest of the eagle kind, but supposed to be the largest bird that flies. He calls it the golden eagle; by the natives it is vulgarly called abon duchn, or father long beard.

FALCONRY, the exercise of taking wild-fowl by means of hawks. There are only two countries in the world where we have any evidence that the exercise of hawking was very anciently in vogue. These are Thrace and Britain. In the former it was pursued merely as the diversion of a particular district, if we may believe Pliny (b. x. 8.), whose account is rendered obscure by the darkness of his own ideas of the matter. The primæval Britons, with a fondness for the exercise of hunting, had also a taste for that of hawking; and every chief among them maintained a considerable number of birds for that sport. To the Romans this diversion was scarcely known in the days of Vespasian; yet it was introduced immediately afterwards. Most probably they adopted it from the Britons; but we certainly know that they greatly improved it by the introduction of spaniels into the island. In this state it appears among the Roman Britons in the sixth century. Gildas, in a remarkable passage in his first epistle, speaks of Maglocunus, on his relinquishing the sphere of ambition, and taking refuge in a monastery; and proverbially compares him to a dove, that hastens away at the noisy approach of the dogs, and with various turns and windings takes her flight from the talons of the hawk.

In after-times, hawking was the principal amusement of the English: a person of rank scarcely stirred out without his hawk on his hand; which, in old paintings, is almost the criterion of nobility. Harold, afterwards king of England, when he went on a most important embassy into Normandy, is painted embarking with a bird on his finger, and a dog under his arm: and in an ancient picture of the nuptials of Henry VI. a nobleman is represented in much the same manner; for in those days, "it was thought sufficient for noblemen to winde their horn, and to carry their hawk fair, and leave study and learning to the children of mean people."

The expense was great that sometimes attended this sport. In the reign of James I. sir Thomas Monson is said to have given 1000*l.* for a cast of hawks; we are not then to wonder at the rigour of the laws that tended to preserve a pleasure which was carried to such an extravagant pitch. In the 34th of Edward III. it was made felony to steal a hawk; to take its eggs, even in a person's own ground, was punishable with imprisonment for a year and a day, besides a fine at the king's pleasure: in queen Elizabeth's reign, the imprisonment was reduced to three months; but the offender was to find security for his good behaviour for seven years, or lie in prison till he did.

The falcons or hawks that were in use in these kingdoms are now found to breed in Wales, and in North Britain and its isles. The peregrine-falcon inhabits the rocks of Caernarvonshire. The same species, with the gyr-falcon, the gentil, and the gos-hawk, are found in Scotland, and the latter in Ireland.

We may here take notice, that the Norwegian breed was, in old times, in high esteem in England: they were thought bribes worthy of a king. Jeoffrey Fitzpierre gave two good Norway hawks to king John, to obtain for his friend the liberty of exporting 100 cwt. of cheese; and Nicholas the Dane was to give the king a hawk every time he came into England, that he might have free liberty to traffic throughout the king's dominions.

They were also made the tenures that some of the nobility held their estates by, from the crown. Thus sir John Stanley had a grant of the isle of Man from Henry IV. to be held of the king, his heirs, and successors, by homage and the service of two falcons, payable on the day of his or their coronation. And Philip de Hastang held his manor of Combertoun, in Cambridgeshire, by the service of keeping the king's falcons.

Falconry, though an exercise now much disused in comparison with what it anciently was, does yet furnish a great variety of significant terms, which still obtain in our language. Thus, the parts of a hawk have their proper names. The legs from the thigh to the foot, are called *arms;* the toes the *petty singles;* the claws the *pounces.* The wings are called the *sails;* the long feathers the *beams;* the two longest, the *principal feathers;* those next, the *flags.* The tail is called the *train;* the breast-feathers the *mails;* those behind the thigh the *pendant feathers.* When the feathers are not yet full-grown she is said to be *unsummed;* when they are complete, she

is *summed:* the craw, or crop, is called the *gorge;* the pipe next the fandament, where the fæces are drawn down, is called the *pannel:* the slimy substance lying in the pannel is called the *glut:* the upper and crooked part of the bill is called the *beak;* the nether part, the *clap;* the yellow part between the beak and the eyes, the *sear* or *sere:* the two small holes therein, the *nares.*

As to her furniture: the leathers with bells buttoned on her legs, are called *bewits.* The leathern thong, whereby the falconer holds the hawk, is called the *lease* or *lash;* the little straps, by which the lease is fastened to the legs, *jesses;* and a line or packthread fastened to the lease, in disciplining her, a *creance.* A cover for her head, to keep her in the dark, is called a *hood;* a large wide hood, open behind, to be worn at first, is called a *rufter-hood:* to draw the strings, that the hood may be in readiness to be pulled off, is called *unstriking the hood.* The blinding a hawk just taken, by running a thread through her eyelids, and thus drawing them over the eyes, to prepare her for being hooded, is called *seeling.* A figure or resemblance of a fowl, made of leather and feathers, is called a *lure.* Her resting-place, when off the falconer's hand, is called the *perch.* The place where her meat is laid, is called the *hack;* and that wherein she is set while her feathers fall and come again, the *mew.*

Something given a hawk to cleanse and purge her gorge, is called *casting.* Small feathers given her to make her cast, are called *plumage.* Gravel given her to help to bring down her stomach is called *rangle.* Her throwing up filth from the gorge after casting is called *gleaming.* The purging of her grease, &c. *enseaming.* Her being tuffed is called *gurgiting.* The inserting a feather in her wing in lieu of a broken one is called *imping.* The giving her a leg, wing, or pinion of a fowl to pull at is called *tiring.* The neck of a bird the hawk preys on is called the *inke.* What the hawk leaves of her prey is called the *pill* or *pelf.*

There are also proper terms used for several actions. When she flutters with her wings, as if striving to get away, either from the perch or fist, she is said to *bate.* When, standing too near, they fight with each other, it is called *crabbing.* When the young ones quiver, and shake their wings in obedience to the elder, it is called *cowring.* When she wipes her beak after feeding, she is said to *seak.* When she sleeps, she is said to *jouk.* From the time of exchanging her coat till she turn white again, is called her *intermewing.* Treading is called *cawking.* When she stretches one of her wings after her legs, and then the other, it is called *mantling.* Her dung is called *muting;* when she mutes a good way from her, she is said to *slice;* when she does it directly down, instead of yerking backwards, she is said to *slime;* and when if it be in drops, it is called *dropping.* When she sneezes it is called *sniting.* When she raises and shakes herself she is said to *rouze.* When, after mantling, she crosses her wings together over her back, she is said to *warble.*

When a hawk seizes she is said to *bind.* When, after seizing, she pulls off the feathers she is said to *plume.* When she raises a fowl aloft, and at length descends with it to the ground, it is called *trussing.* When, being aloft, she descends to strike her prey, it is called *stooping.* When she flies out too far from game she is said to *rake.* When, forsaking her proper game, she flies at pyes, crows, &c. that chance to cross her, it is called the *check.* When, missing the fowl, she betakes herself to the next check, she is said to *fly on head.* The fowl or game she flies at is called the *quarry.* The dead body of a fowl killed by the hawk is called a *pelt.* When she flies away with the quarry she is said to *carry.* When in stooping she turns two or three times on the wing, to recover herself ere she seizes, it is called *cancelicring.* When she hits the prey, yet does not truss it, it is called *ruff.* The making a hawk tame and gentle is called *reclaiming.* The bringing her to endure company, *manning* her. An old staunch hawk, used to fly and set example to a young one, is called a *make-hawk.*

The reclaiming, manning, and bringing up a hawk to the sport, is not easy to be brought to any precise set of rules. It consists in a number of little practices and observances, calculated to familiarize the falconer to his bird, to procure the love of it, &c.

When your hawk comes readily to the lure, a large pair of luring bells are to be put upon her; and the more giddy-headed and apt to rake out your hawk is, the larger must the bells be. Having done this, and she being sharpset, ride out in a fair morning, into some large field unencumbered with trees or wood, with your hawk on your hand; then having loosened her hood, whistle softly to provoke her to fly; unhood her, and let her fly with her head into the wind; for by that means she will be the better able to get upon the wing, and will naturally climb upwards, flying a circle. After she has flown three or four turns, then lure her with your voice, casting the lure about your head, having first tied a pullet to it; and if your falcon come in and approach near you, cast out the lure into the wind, and if she stoop to it reward her.

You will often find, that when she flies from the first, she will take stand on the ground: this is a fault which is very common with soar-falcons. To remedy this, fright her up with your wand; and when you have forced her to take a turn or two, take her down to the lure and feed her. But if this does not do, then you must have in readiness a duck sealed, so that she may see no way but backwards, and that will make her mount the higher. Hold this duck in your hand, by one of the wings near the body, then lure with the voice, to make the falcon turn her head; and when she is at a reasonable pitch, cast your duck up just under her; when, if she strikes, stoops, or trusses the duck, permit her to kill it, and reward her by giving her a reasonable gorge. After you have practised this two or three times, your hawk will leave the stand, and, delighted to be on the wing, will be very obedient.

It is not covenient, for the first or second time, to show your hawk a large fowl; for it frequently happens, that they escape from the hawk, and she, not recovering them, rakes after them: this gives the falconer trouble, and frequently occasions the loss of the hawk. But if she happens to pursue a fowl, and being unable to recover it, gives it over, and comes in again directly, then cast out a sealed duck: and if she stoops and trusses it across the wings, permit her to take her pleasure, rewarding her also with the heart, brains, tongue, and liver. But if you have not a quick duck, take her down with a dry lure, and let her plume a pullet and feed up-

on it. By this means a hawk will learn to give over a fowl that rakes out, and, on hearing the falconer's lure, will make back again, and know the better how to hold in the head.

Some hawks have a disdainful coyness, proceeding from their being high-fed; such a hawk must not be rewarded though she should kill: but you may give her leave to plume a little; and then taking a sheep's heart cold, or the leg of a pullet, when the hawk is busy pluming, let either of them be conveyed into the body of the fowl, that it may savour of it; and when the hawk has eaten the heart, brains, and tongue of the fowl, take out what is inclosed, call her to your fist, and feed her with it; afterwards give her some of the feathers of the fowl's neck, to scour her, and make her cast.

If your hawk is a stately high-flying one, she ought not to take more than one flight in a morning; and if she is made for the river let her not fly more than twice: when she is at the highest, take her down with your lure; and when she has plumed and broken the fowl a little, feed her, by which means you will keep her a high-flier, and fond of the lure.

FALDFEY, or FALDFEE, a rent or fee paid by some customary tenants, for liberty to fold their sheep on their own lands.

FALL, is the name of a measure of length used in Scotland, and containing six ells of that country.

FALL, in the sea language, that part of the rope of a tackle, which is hauled upon. Also when a ship is under sail, and keeps not so near the wind as she should do, they say she falls off; or when a ship is not flush, but has risings of some parts of her decks more than others, it is called falls.

FALLOPIAN TUBES. See ANATOMY.

FALLOWING *of land*. See HUSBANDRY.

FALSE, in music, an epithet applied to theorists to certain chords, called false, because they do not contain all the intervals appertaining to those chords in their perfect state: as a fifth, consisting of only six semitonic degrees, is denominated a false fifth. Those intonations of the voice which do not truly express the intended interval are also called false, as well as all ill-adjusted combinations; and those strings, pipes, and other sonorous bodies, which, from the ill-disposition of their parts, cannot be accurately tuned. Certain closes are likewise termed false, in contradistinction to the full or final close. See CLOSE.

FALSETTO, (Ital.) that species of voice in a man, the compass of which lies above his natural voice, and is produced by artificial constraint.

FALSIFYING, in law, the proving a thing to be false. The falsifying a record, is where a person purchases land of another, who is afterwards outlawed for felony; in this case, he may falsify the record as to the time when the felony is supposed to have been committed, and also as to the point of the offence. But in the case where a person is found guilty by verdict, such purchaser shall only falsify the time. To falsify a recovery may be done by the issue in tail, where it is suffered by a tenant for life.

FALSO RETURNO BREVIUM, a writ that lies against a sheriff for false returning of writs he had got to execute.

FALSO BORDONE, in music, a term applied in the early days of descant to such counterpoint as had either a drone bass, or some part constantly moving in the same interval with it.

FALX, in anatomy, a process of the dura mater placed between the two hemispheres of the brain, and resembling a reaper's sickle.

FAMILIARS *of the inquisition*, are people that assist in the apprehending of such persons as are accused, and carrying them to prison; upon which occasion, the unhappy person is surrounded by such a number of these officious gentlemen, that there is no possibility of escaping out of their hands. As a reward of this base employ, the familiars are allowed to commit the most atrocious actions, to debauch, assassinate, and kill, with impunity.

FAN, an instrument used in husbandry. See HUSBANDRY.

FANDANGO, a dance much practised in Spain, and of which the natives of that country are particularly fond. Its air is lively, and much resembles the English hornpipe.

FANTASIA, (Ital.) the name generally given to a species of composition, supposed to be struck off in the heat of imagination, and in which the composer is allowed to give free range to his ideas, and to disregard those restrictions by which other productions are confined. Some writers limit the application of this term to certain extemporaneous flights of fancy; and say, that the moment they are written, or repeated, they cease to be fantasias. This, they add, forms the only distinction between the fantasia and the capricio. The capricio, though wild, is the result of premeditation, committed to paper, and becomes permanent: but the fantasia is an impromptu, transitive, and evanescent; exists but while it is executing, and when finished is no more. Fantasias being, however, daily written and published, it is evident in which of the above senses the word is now to be understood.

FARINA FŒCUNDANS, among botanists, the impregnating meal or dust on the apices or antheræ of flowers; which being received into the pistil, or seed-vessel of plants, fecundates the rudiments of the seeds in the ovary, which otherwise would decay and come to nothing.

The manner of gathering the farina of plants for microscopical observation is this: Gather the flowers in the midst of a dry sun-shiny day when the dew is perfectly off; then gently shake off the farina, or lightly brush it off with a soft hair-pencil, upon a piece of white paper; then take a single talc of isinglass between the nippers, and, breathing on it, apply it instantly to the farina, and the moisture of the breath will make that light powder stick to it. If too great a quantity is found adhering to the talc, blow a little of it off; and if there is too little, breathe upon it again, and take up more. When this is done, put the talc into the hole of a slider; and applying it to the microscope, see whether the little grains are laid as you desire, and if they are, cover them up with another talc, and fix the ring, but care must be taken that the talcs do not press upon the farinæ in such a manner as to alter the form.

FARLEY, or FARLIEU, money paid by tenants in the west of England, in lieu of a heriot. See HERIOT.

FARM, or FERM, signifies the chief messuage in a village, or any large messuage on which land belongs, meadow, pasture, wood, common, &c. and which has been used to let for term of life or years, under a certain yearly rent payable by the tenant for the same. See HUSBANDRY.

FARMER, among miners, signifies the lord of the field, or the person who farms the lot and cope of the king.

FARRIERY, the art and profession of the farrier, which have comprehended, from the earliest even to the present period, the medical and surgical care of the horse, as well as that of manufacturing and fitting him with shoes. These men, as labourers of iron, were originally termed ferrers, or ferriers, from the Latin word *ferrum*, iron, and their craft ferriery; which word has since, either by a very usual corruption or improvement of language, been changed to farriery. This term remains yet in general use to its fullest extent, and not inaptly; since notwithstanding the laudible attempts of many enlightened men at various periods, our blacksmiths form a very large majority of horse surgeons and physicians. Nor is such defect peculiar to this country, but prevails in an equal degree throughout Europe; even in Italy and France, countries which preceded us many centuries in veterinary science, and from which indeed we have derived its elements.

On the establishment of a college, in England, in 1790, for the instruction of pupils in animal medicine and surgery, under a French professor, (Saintbel) was imported also from France the term *veterinary*, and the veterinary art has been since substituted for farriery by practitioners of liberal education. The supposed derivation of the term veterinary is from the participle *vectum*, of the Latin verb *veho*, to carry; *quasi* vecterinary, thence applied to the care of animals which carry, or beasts of burden. The change to veterinary was easy and in course; and if, according to the opinions of some, we ought to revert to the radical orthography, and write ferriery instead of farriery, a parity of reasoning, and desire of close adherence to the root, would induce us to retain the *c*, and pronounce the word vecterinary. It is easy to conceive what revolutions in language such attempts would occasion if generally put in practice; but by no means easy to discover the utility of a capricious and partial adoption of such changes in particular words.

The term veterinary was originally used by the Latins, (Vegetius) and has a more extensive import than our farriery, which relates to the horse solely; whereas the former comprehends the care, both in health and in a state of disease, of all those animals domesticated for the laborious service or food of man. In a history of the general science those branches may, however, be properly considered together.

From the manifest great consequence of the services of the domestic animals to man, in a state of civilization, they have, from a very remote period of antiquity, been the objects of his study and attention, both as to their ordinary management, and that which was requisite for them in a state of disease: for the latter a peculiar system was formed, including a meteria medica and general mode of treatment considerably distinct from those in use with human patients. Of the authors of this system, whether Greek or Roman, nothing worth notice has been handed down beyond an occasional citation of names, to be found in Columella the Roman writer, who lived in the reign of Tiberius, and treated at large on the general management of cattle; and in Vegetius Renatus, who lived two centuries afterwards, and wrote more professedly on animal diseases. Both these authors have treated their subject in elegant and classical Latin; and the latter most particularly has urged, in very eloquent and forcible language, the necessity of a liberal cultivation of the veterinary art, as well on the score of profit as of humanity. It ought to be remembered, however, that neither of these authors had the benefit of any professional acquaintance with medicine or surgery, obscure and imperfect as were those sciences in their days; and that no ancient treatise on the diseases of animals, written by a professional man, has descended to posterity. Nor is this in the smallest degree to be regretted, since we not only find in the authors abovementioned a sufficient field for the satisfaction of our curiosity, but also the most ample proofs of the irrationality of ancient principles and practice, and their total inapplicability to modern occasions. (Lawrence's General Treatise on Cattle.) On veterinary anatomy and physiology no attempts at discovery or improvement are to be traced in those writers, a singular defect considering the progress which had been made in Egypt and Greece, in both the human and comparative anatomy. Celsus is the only physician of eminence among the ancients who is reported to have written on veterinary medicine, a part of his works which has not survived; nor is probably the loss we have thereby suffered very considerable. Xenophon is the oldest veterinary writer on record; but his treatise is confined to the training and the management of the horse for war and the chace. With respect to the fragments of ancient Greek and Latin veterinary writers, collected and published by Ruellius, chief marshal, or farrier to Francis I. king of France, they appear to have been generally the works of military men, or other lovers of the horse; perhaps none of them were of medical education. We learn from the works of one of them, (Theomnestus) which is confirmed also by others, that the ancients had a knowledge of the disease called the glanders in horses and other cattle, which was denominated in those days the moist malady. The chief merit of the ancient veterinary writers consists in their dietetic rules and domestic management; they were in the habit of purging their animals, but in other respects their medical prescriptions appear to us an inconsistent and often discordant jumble of numerous articles, devoid either of rational aim, or probable efficacy. In the operations of surgery, particularly in phlebotomy, and indeed in the various methods of manual treatment and controul of their animals, the ancients were far more skilful; and what they have left on the symptoms of diseases, if of no consequence in the present advanced state of science, still serves to demonstrate that they had not been inattentive observers of animal diseases, however inferior they might be in their methods of cure. These ancient writers are yet to be esteemed superior, not only in learning and eloquence, but in professional utility, to the majority of their pupils of the fifteenth, sixteenth, and seventeenth centuries.

On the revival of learning in Europe, at the above periods, the works of the ancient veterinary writers were eagerly sought and translated in Italy and France. At the same dawn of opening light and enthusiasm for the resuscitation and enlargement of the bounds of useful science, the anatomy and physiology of the human body became the grand objects of pursuit in the Italian schools. Veterinary anatomy followed in course; and the descriptive labours of Ruini and others on the body of the horse, have not only served for a groundwork and model to all the schools of Europe since; but succeeding discoveries and improvements, notwithstanding the vast advantage of a general diffusion of light, have not been hitherto sufficiently considerable to detract in any eminent degree from the well-earned fame of those early and original anatomists. Veterinary medicine was now generally cultivated, and in some instances, under regular medical professors. We find the following names in a list of those who had written on the *res veterinaria* in Italy during that period:—Laurentius Russius, Camerarius, Apollonius, Horatio, Albeterio, Grilli, Cæsar Fiaschi, Evangelista; and afterwards in Germany and France, Gresson, Libal, Wickerus, La Brove, Vinet. Every branch of the equine economy, whether relative to harness and trappings, equitation and military menage, or riding the great horse, the methodical treatment of the hoof, with the invention of various forms of iron shoes, and their scientific adaptation, were pursued with general assiduity and success. In this latter department Cæsar Fiaschi distinguished himself; and either invented or recommended the welted shoe, proposing a substitute for calkens and frost-nails, which it appears were then in use, as well as the *lunette*, or short half-moon shoe. Those horse-nails of peculiar form, of late years recommended as a new and useful invention, under the name of concave nails, were well known in those times of which we now speak. In fact, considerable progress was made towards a perfect system of horse-shoeing, which however declined and retrograded during a long interval, until its revival in France and England within the last fifty years. Evangelista, of Milan, distinguished himself in the breaking or education of the horse, and to him is attributed the invention of the martingale.

The new veterinary science having diffused itself over a great part of the continent of Europe, could scarcely fail of occasional communication with England, where the care of diseased animals had been committed immemorially to leeches and farriers, persons generally belonging to the most illiterate class of society. It is probable that such communications became frequent during the reign of the first Tudors; for we learn from Blundeville, who wrote in the time of Elizabeth, that French and German farriers and riding-masters were not only employed by the queen, but in general by the nobility and gentry of the country. Yet the improvements in consequence of foreign aid, with regard to the medical and surgical branches at least, were by no means great, extending our view from the period of which we now speak, to the early part of the eighteenth century. No medical name appears during that long interval upon our veterinary list, nor any one of the smallest scientific pretension, we mean as far as respects the medical, anatomical, or surgical branches, that of Snape excepted, who was farrier to Charles II. and whose family, it appears by his book, had served the crown in that capacity upwards of two hundred years. Snape's anatomy of the horse proves him to have been a well-informed farrier. His anatomical system, arrangements, and nomenclature, were in course drawn from the Italian school; but he dissected, and his descriptions were confirmed by his own observation. His numerous plates are bold, accurate, and handsomely executed. Whether or not he published the book of cures which he promised, we are uninformed, but he was doubtless far better qualified for that task than those of his profession upon whom that branch of the veterinary art unfortunately devolved. Stevens, Martin, Clifford, Morgan, were very early writers among the leeches and farriers. The book of Mascal, farrier to James I. is most laughably illiterate, and we cannot help wondering with a late author how such a book could possibly pass through numerous editions in a learned age, and which even possessed learned and rational books on the same subject. The above list may be concluded with De Grey and the celebrated Gervase Markham, a contemporary of Blundeville, who continued to publish perhaps until after the Restoration, and whose works were stuffed with every absurd, barbarous, and abominable juggling trick, as well as with every useful invention which had issued from the brains of either ancients or moderns. As a specimen of the medical part of the horse leech-craft of Markham, he prescribes human ordure in certain cases for the horse, both externally and internally. Yet this man's works had a most rapid and universal sale, and continued in repute until the days of Gibson, and even long afterwards among the country leeches and farriers. It must be allowed that Markham's book contained the fullest detail of the practice of the farrier, with a delineation of his instruments, not materially different from those in present use.

Blundeville wrote sensibly and respectably on the general subject of the horse, according to the continental, the then fashionable practice. Baret in the succeeding reign, that of James I. wrote a learned treatise, entitled an Hipponomie, or the Vineyard of Horsemanship, in which he ably, and from obvious great experience, discusses all the relative branches, including the principles and practice of the race-course, and of that system of equitation peculiar to, and so generally prevalent in, England. The huge folio of the duke of Newcastle gives us the regular manege of the horse from the continental schools, with an account of the different races of the animal, in which his grace was a connoisseur of high celebrity. Throughout the same interval veterinary science in France seems to have remained almost exclusively in the hands of the marshals or farriers, amongst whom Solleysel was the most celebrated writer of the seventeenth century; his works were afterwards abridged and translated into English by sir William Hope.

Until the reign of George I. the medical care of horses and other domestic animals was confided entirely to the classes of farriers, leeches, and cow-doctors. Considering the superior value of animals in this country, the former neglect of them would appear astonishing, did it not subsist at this moment in so considerable a degree;

and that from causes easily ascertainable, but with difficulty to be surmounted. The medical system of the farriers, as delivered in their books, formed a strange medley of ancient metaphysical notions, blended with deductions from the vague and uncertain experience of illiterate men. Much of it seemed the result of mere ignorance and caprice; no little, of pure distraction. For example, in a case of farcy, De Grey orders the medicine to be administered to the ears of the horse, and stitched up therein. In case of lameness a turf was to be cut and secreted; and in proportion as the turf decayed and wasted, so would the lameness! Various of their operations, in which no shadow of reason or possible utility seems discernible, were pursued with measures of horrible barbarity; for example, in Markham, the cure by the fire or knife for the falling of the crest! These men seem to have exhausted their wits in the discovery of ingenious and knowing feats of cruelty; and it is a phrase with Markham, 'other torments there are.' The art of shoeing the horse had retrograded from the original practice of the Italian farriers, which, however imperfect, yet formed a sufficient outline for a rational system. It had become the universal practice to pare away the frog and soles of the horse's foot; and by way of making amends for such loss of substance, to substitute a shoe of massive iron, so long as to project beyond the heels. It must however be acknowledged, that a far more rational practice obtained amongst those who had the superintendance of that peculiar species of horses appropriated to the business of the turf, not only with respect to the shoeing, but every other branch of management; and as the foreign and racing species has been the grand source of improvement for the saddle and coach breeds; so the jockey system of equitation and general treatment of the horse, allowing its progressively amending defects, has ever possessed a characteristic and acknowledged superiority.

Such was the state of farriery and veterinary practice in the early part of the eighteenth century, when the former, or horse medicine and surgery, attracted the attention of Wm. Gibson, who had acted in queen Anne's wars as an army-surgeon, and appears by his writings to have been a man of much practical knowledge and sound judgment. He was the first regular professional man who attempted to improve veterinary science, which he effected in a plain and popular way, grounded on the analogy between the human and brute physiology, in course between human and animal medicine. The appearance of Gibson's book on farriery forms an era in veterinary annals; and his system in fundamentals has ever been, and is at this moment, the basis of our superior veterinary practice. He lived to publish a new edition of his chief work, about the middle of the eighteenth century. Dr. Bracken, a physician of Lancaster, a vulgar, desultory, captious, and petulant writer, yet a profound and enlightened reasoner, and of great ability in his profession, in a few years followed the laudable example of Gibson, and turned his attention to veterinary medicine. He was an exquisite practical judge of the animal on which he treated; and his work on farriery is a standard with respect to the jockey or peculiar English system, a branch which had been left untouched by Gibson. Bartlet, a surgeon in Bow-street, Covent-garden, was a most respectable, intelligent, and useful compiler from Gibson and Bracken, whose labours he circumscribed and improved. He also first introduced the new, but hypothetical and impracticable, system of short shoeing, which had then lately been promulgated in France by the sieur La Fosse, a farrier of considerable science, and a great practical veterinary anatomist. Bartlet candidly gave the rules of La Fosse for shoeing horses, without pretending to any great practical knowledge of the subject; and these rules, speculative as they were, had yet the beneficial effect of operating a considerable improvement on English practice. Fortunately the affair was soon after taken in hand by William Osmer, a surgeon and a sportsman, who had great practical knowledge of the horse, and particularly of the race-horse, that species which, whilst it improves every other, requires the greatest attention, and in an especial manner with regard to shoeing and the treatment of the feet. Osmer commenced veterinary surgeon, and published an excellent and practical, although whimsically written book on horse-shoeing, in which he reduced the speculative rules of La Fosse to the standard of his own and of English experience. His book has not probably been hitherto excelled in point of utility; and being written in a plain and popular way, is adapted to the capacities of shoeing-smiths. The earl of Pembroke also wrote a short and excellent treatise on the same subject, practical horse-shoeing and case of the feet, and on the education of the military horse. Berenger, about the same time, published a respectable work on the grand manege. Mr. Clarke, the king's farrier for Scotland, has published two valuable treatises on shoeing, and on prevention of the diseases of horses.

To revert to the commencement of the Gibsonian era. It is to be lamented that the success with which Gibson's and Bracken's improved farriery was attended did not stimulate the attempts of some regular medical men to undertake the improvement of veterinary practice in favour of our other domestic animals, and to deliver them and their proprietors from barbarous and illiterate leech-craft. Doubtless a want of encouragement must be looked upon as one of the chief causes of this defect. A book indeed appeared about the middle of the eighteenth century, under the name of Topham, treating of the diseases of horned cattle, but it proved to be a mere compilation, in which however were collected some useful hints with respect to management. As Gibson's Farriery had given rise to a great number of compilations, so Topham's book served the same purpose to the cow-doctors, many of whom copied Topham word for word, and boldly published these excerpts as the result of their own long experience and practice. Such has proved to be almost invariably the deceptive practice of this description of writers; whence the great number of similar publications, and the constant well-founded complaints against them. Mr. Lawrence, in his late General Treatise on Cattle, has taken the pains to ascertain various facts of this kind, and has given the outline of a rational system of veterinary practice, calculated for cattle and sheep, recommending the pursuit to medical men, and the liberal encouragement of such to the proprietors of cattle, and particularly to the agricultural societies.

The eighteenth century was abundantly fruitful in veterinary pursuits and publications. France took the lead; but a zeal for the improvement of this branch of science also pervaded Germany and the northern states, and colleges were established in various countries, wherein the science has been since regularly cultivated. Baron Haller collated the various continental writers on black cattle and sheep; another catalogue of them may also be found in the Giournal di Literati of Italy. Since these collections, the number of veterinary writers has been immense on the continent, not improbably for a reason already assigned. Few or none of them have been translated into our language, excepting detached parts of the works of the eminent French writers, La Fosse and Bourgelat. Our late professor Saintbel was a disciple of these celebrated veterinarians, and drew his geometrical proportions of the race-horse Eclipse from the tables of the latter. The truth and correctness of these geometrical principles have been since controverted by Mr. Wilkinson. Indeed, several speculative positions laid down in these tables do not accord with English practical experience; nor is the continental veterinary system, it is said, altogether calculated for the practice of this country, one great proof of which presents itself in the failure of the celebrated method of shoeing by La Fosse. The French have improved the anatomical and surgical branches of the veterinary art, rather than the medical; the English have made the greatest improvements in the latter: it is not improbably a parallel case with respect to human medicine.

Since the establishment of a veterinary college at St. Pancras, near London, in 1792, a great number of veterinary surgeons, receiving their diploma from thence, have been dispersed in the army and throughout the country, to a great national advantage, in the surgical and medical treatment of horses. A number of farriers also annually take the advantage of improving themselves at this seminary; but it is to be lamented that the light of veterinary science has hitherto shined but dimly and imperfectly on the other domestic animals. A great number of veterinary publications have issued from the press within this last period; and the two professors Saintbel and Coleman, with Messrs. White, Boardman, Blane, and many others, have laudably and usefully distinguished themselves in this way. Mr. Blane appears to have taken great pains in a new branch of veterinary science, as it relates to that useful domestic the dog. He has also published the anatomy of the horse. But the anatomical drawings and engravings of the bones, muscles, and many of the blood-vessels of the horse, of the justly celebrated horse-painter Stubbs, are held superior to any thing we possess of this kind.

The objects of farriery we have shown, are the anatomy, physiology, pathology, medical and surgical care, and shoeing, of the horse. Dr. Crooke, quoted by Snape, affirms, that the motions of the heart, the arteries, the midriff, the brain, and guts, are the same in beasts as in men. Mr. Bracey Clarke observes, that "to describe each part of the horse individually and separately, would be often only repeating the more elaborate descriptions of the human anatomy, more frequently than those but little conversant with this subject would suspect. Many of the viscera, and even the myology of the trunk and extremities, often correspond in their principal circumstances." Snape further says, that "in some regards anatomy is more necessary to farriers than to physicians, in order to find out disorders; for besides the pulse and the urine, and the pathognomonic signs of each distemper, the physicians are assisted in their enquiries, moreover, not to say chiefly, by the complaints and relations of the patients themselves; whereas a farrier, having to do with a dumb creature, must be very curious in his knowledge of the parts, with their offices, and of the sympathy or consent that one part hath with another; or else, seeing all his information must be of his own hammering out, he is like to make but a short discovery of the distemper." Add to the above observations, the analogy which modern experience has found to subsist between human and animal medicine, so far as our domesticated animals are concerned; and it will appear to whom veterinary science must necessarily be confined; and that an illiterate and ignorant class, whose laborious occupation must for ever preclude study and reflection, are totally incapable of the practice of medicine, whether human or animal. Thus the countenance and encouragement of so gross a deviation from rectitude and common sense must be constantly attended with loss and disappointment to the proprietors, and cruelty to their animals, exclusive of the moral breach of holding out to a numerous set of men the arts of imposition and legerdemain as a livelihood. The branches of the veterinary art, justly appropriate to the farrier and the cow-leech, are shoeing the horse and the labouring-ox, administering drenches, obstetric practice, bleeding, firing, and common surgical operations, under the guidance of a scientific veterinarian. Even shoeing, which seems most to appertain to the province of the common operator, has never been, in a single instance, improved by that class, but invariably by men of science: on the contrary, every improvement has met the strenuous opposition of the common farrier, until he has been gradually drawn into it, and almost imperceptibly to himself. Nor is the province we have assigned to these people, by any means, narrow or confined, but most ample, and affording a fair scope for both industry and good natural talents. Yet far be it from our intention to exclude them from the benefits either of attending the veterinary college or of consulting useful and practical books, which, in fact, are the true and only means to accomplish them in the fair and proper objects of their profession. We neither counsel nor desire any thing farther, than that such men, who may be much more suitably and advantageously employed, be as little as possible permitted to dabble in medicine.

It has of late been averred, in a sense far too general, that analogies fail, as well in anatomy as in the effects of medicine, between the human and those animals of which we treat. It is true the latter are quadrupeds, and their structures is of greater magnitude, and necessarily varies from ours; their integuments are thicker, and their general substance more solid. It requires, therefore, and the proportion has been long ascertained with sufficient accuracy, the application of a more powerful stimulus, in all given cases; in many, peculiar modes of administration. Certain common articles of the materia medica, namely, rhubarb, jalap, and the pur-

ging salts, it has been said of late, have no perceptible effects on the body of the horse, an assertion which ought to be received with a degree of caution. It is true, jalap and rhubarb, which were formerly, and particularly by Gibson, recommended as ingredients in purgative formulæ, will scarcely have any purgative effect if used by themselves; the latter, however, at least is certainly capable of answering many beneficial intentions in veterinary medicine; but its high price is doubtless a strong objection. Purging salts, it is acknowledged, will not often excite liquid dejections in horses, although they will in cows; but in the former, judiciously administered, they evacuate great loads of softened excrement, have excellent cooling and diuretic properties, and are well calculated for horses much confined in hot stables, and for those of delicate constitutions. All, or the far greater part, of the most powerful and efficacious medicines, both of the tonic and debilitating class, have a signal and analogical effect on the constitution of the horse. Nor is the common opinion, that the horse, living upon plain and simple food, has very little or no occasion for medicines, deserving of the smallest attention, any otherwise than as applied to the horse ranging at large in a state of nature. Labouring in the service of man, and confined to the dense and foul air of the stables, often in a constant state of luxurious repletion, exposed also to perpetual alternations of heat and cold, his body becomes subject to a variety of diseases, some of them of a most malignant type; and with respect to accidents he must, from the nature of his severe services, be necessarily subject to a greater variety than any other animal. The above common-place opinion has ever been brought particularly to bear against the practice of purging horses, by which nevertheless they receive the most obvious and important benefits, and of which they seldom fail to have occasional need, whilst kept at hard meat in the stable. In fact, considering the obstruction and heat to which they are liable from the vast volume of their intestines, and the dryness and solidity of the food with which they are fed, it should seem probable that no animals stand more in need of artificial evacuants. The very circumstance of the length of their intestines has indeed been adduced as a proof of the impropriety and even danger of administering to them purgative medicines; and various instances of fatal effects therefrom have been proved. Sotteysel, the French writer, argued in this way; and advised the substitution of perspirants and diuretics; and notwithstanding the eminent success which every one accustomed to the superior management of horses, has experienced from purging them, the above superficial and groundless notion is occasionally revived even at present. The grand object is the removal of visceral infraction and obstruction, the common parent of almost every morbid evil in the horse; and this can at no rate be effected by diuretics, although they gave a partial, but illusory, and thence dangerous relief.

Nor are alteratives, in a general view, so advantageous as mild and well apportioned purges, which seem, in a particular manner, adapted and friendly to the constitution of the horse, filling him with renovated spirit and vigour, and increasing his appetite and strength. Purging the horse is perhaps to be considered as an English practice, alteratives and diuretics being in more general use on the continent; and with respect to the danger of purging, the experience of a century has proved that to consist merely in the abuse and the use of bad drugs. Purging composes a material branch of the celebrated jockey or Newmarket system, which, with its imitations, have produced a perfection of habit and condition in the horse, universally admired by foreigners, and peculiar to that country. There is yet another opinion occasionally delivered, which we trust may not be unsuccessfully controverted: we advert to the pretended infant and imperfect state of veterinary science. The science of farriery has long been in a respectable and even mature state in Great Britain, however generally deficient the practice; and we surely have at this time an undoubted right to expect a general and practical improvement.

Horses are particularly subject to catarrhal fever, pneumonia, influenzal and epidemic colds, rheumatism, asthmatic complaints, affections of the liver, colic, and blindness. They also share in common with human nature the maladies of apoplexy, spasm and convulsions, affections of the kidneys and urinary bladder, diabetes, dropsy, fever, and cutaneous affections.

The peculiar diseases of the horse are glanders, farcy, grease, strangles, poll evil or abscess, and they are particularly liable to injury and lameness in the lower extremities.

With respect to their diseases, the glanders, it is well known, has ever been the veterinary opprobrium, nor have we yet, after an infinity of attempts at various periods, advanced one step towards a probability of cure, speaking of the chronic species; nor is such an attainment perhaps an object of much consequence or interest from the length of time the cure must necessarily require, and the little subsequent use to be expected from the patient. The acute or incipient glanders will generally submit to proper remedies and care. The disease is atmospheric and catarrhal, and occasionally, but perhaps not so frequently as in common supposed, caught by contagion of other horses. Oxen and sheep are affected by the glanders; the latter particularly, on being early shorn in cold springs, under the influence of easterly winds. Broken wind in the horse, as its designation would seem to intimate, is irreparable; and there is a relative circumstance for which perhaps it is not easy to account, namely, that if a horse of this description be turned to grass for any length of time, on taking him back to the stable his malady shall be considerably increased, although, perhaps, if continued constantly abroad, he might remain as at first, or experience some amendment. In general, the diseases of horses, supposing skill in the practitioner, and an acquaintance with our best written authorities, may be treated very successfully, and upon a very near level in that respect with the human patient. Amongst, or rather the chief of, those irreparable injuries which the horse, from his hard services, is liable to sustain, must be reckoned repeated strains of the tendons. For a chronic case of that kind it is seldom possible to obtain a cure; and although the only remedy to be depended on is a long run at grass, yet, as has already been observed of broken wind, a horse in a confirmed case of injured tendons, frequently

returns worse from grass than he was whilst in the stable. (Lawrence on Horses.) These injuries are commonly seated about the well-known back sinew of the leg, and among that multitude of tendons (in Snap's language) that descend into the coffin-joint. It has been said that our knowledge in that most important branch, tendinous lameness, has been on the decline since our late unreserved adoption of the principles of the French veterinary school, and accession to the hypothesis of the inelasticity and immobility of tendons, on which it is asserted, that there can exist no such malady as a strained tendon, producing morbid laxity subsequent to inflammation. The new opinion seems to confine the disease to inflammation simply, and the cure to the dispersion of the inflammatory symptoms. Now constant experience has proved, that those merely attendant symptoms may be soon ridded, and yet the strain or lameness continue. (See Bracken on the nature of strain.) This is a most material point of the veterinary art, and involves the great and necessary qualification of detecting the seats of lameness in horses. English horses in general are extremely subject to tendinous lamenesses, both from their natures, as being so much mixed with the delicate racing breed, and from their being forced to more speedy and severe exertions than the horses of any other country. Hence it is said that the best continental veterinarians, as defective in practical experience, are imperfectly skilled in the lamenesses in question, and their proper treatment; and that in order to attain considerable knowledge in this branch, and to be able to ascertain the seats of lameness, it is absolutely necessary for the veterinarian to experiment and practise with the living as well as the dead subject, and to advance far beyond the limits of the riding-school and parade. On this disputed subject, on the turf, on the theory and practice of humanity to animals, and on the purchase, qualifications, and performances of horses, Mr. Lawrence's Philosophical and Practical Treatise may be consulted with much advantage.

The grease.—This discharge seems peculiar to the horse, as in the disorder properly so called, and in molten-grease or the body-founder. The grease in the legs is an extravasation, or bursting from the vessels, and afterwards through the skin, of serum, or simple humour, either from defect of exercise, or any cause of obstructed circulation in those depending parts. Round, fleshy-legged horses, like those, for example, of the old Suffolk cart breed, are constitutionally liable to grease; on the contrary, the flat, sinewy-legged, and in general as horses approach the thorough-bred or racing-kind, they are the least liable to this defect. Want of good grooming, however, the legs remaining in their dirt in the stall, or the horse not lying down, will grease any species of horses. This malady never affects the horse at grass, which points out the readiest cure; and with respect to such as are constitutionally liable, the only way to preserve them sound is to keep them abroad. A slight case in the stable gives way to thorough cleansing and ablution with soap and water, the discharge being afterwards dried up with astringent poultices, lotions, or powders. Purges or alterants may be exhibited according to the nature of the case. A confirmed and inveterate case is extremely difficult of cure, requiring powerful escarotic applications.

Oslets, splents, spavins, ringbone, curb, thoroughpin, &c. are bony excrescences differently posited, originating in an extravasation by pressure of weight or over-exertion, of the mucilage or oil of the joints, which gradually condenses and becomes ossified. Splents and oslets upon the shank, not affecting the joint, may not occasion lameness, and even admit of dispersion and cure by friction, blistering, and repellents, if taken early, and before their substance is become too solid. The ringbone is an ossification or bony swelling, surrounding, as its name expresses, like a ring, the coronet or summit of the hoof; it proceeds from the contiguous small pastern bones. Being suffered to come to maturity, it is incurable by any possible remedy which can leave the horse sound. The spavin is also a preternatural bone, situated on the inside beneath the hock, and extending in its course to the joint. It is generally a hopeless case. Removing the part with a chisel was formerly attempted; but blistering and caustics are the more usual modes of attempt at cure. A very powerful caustic method, recommended by Osmer, was within these few years tried upon a celebrated trotter, but it killed the horse in three days. Perhaps Gibson's cure of a confirmed spavin is the most successful one on record. See his Farriery. The thoroughpin is posited withoutside, and between the bones of the hock. An incipient case may admit a remedy; and we lately witnessed a perfect cure of this malady in about three months by a perpetual blister. The curb is found on the back part of the hock. The bog-spavin withinside, in the cavity of the hock, is a tumour frequently of considerable bulk, of the nature of the windgall. It produces lameness; and that part of the horse, although generally forgotten, should be examined in purchase.

Windgalls are well-known distinct tumours on the pastern-joints, filled with extravasated fluid, which either forms capsules or bags for itself, or such bags are an enlargement of the natural bursæ mucosæ, or mucous capsules, which are found wherever tendons pass over each other, or over any solid part, and serve the purpose of lubricating with their mucus those tendons. Horses are in general subject to this infirmity in proportion to the racing blood they have; and we have seen common bred hacks, in which no labour would produce a windgall. Work will generally bring them more or less; but bandage and astringent lotions, with runs abroad, and the loose stable, are the only preventives. The general palliative remedies are as above, and blistering. When they feel tense and elastic, they may not be an immediate occasion of lameness; but if flabby and inelastic, and of considerable bulk, the tendons are debilitated, and there can be little expectation of soundness. Bracken made a successful experiment of opening, and discharged the fluid of the bog-spavin; and after him, Lawrence that of the windgall. See their accounts.

Corns are bruises or compressions of the horney sole near the quarters; if dry, to be pared out with the knife, and treated with spirituous and healing applications, applying the bat-shoe, if it is necessary to work the horse.

The sand-crack is a cleft in the external part of the

hoof either vertical or with the grain, occasioned by too great dryness in course, and to be prevented by the opposite. Rest the horse, bind the hoof, pare and dress the part. Gibson, in some cases, used the cautery moderately heated.

The quittor, in French *javart*, is a hard round lump or excrescence on the coronet, between hair and hoof, on the one or the other, but usually on the inside quarter of the foot; confirmed, it is a very bad case, generally inducing in the cure the ill consequence of a false quarter or seam adown the foot, from loss of substance; subsequently to which the horse is seldom, perhaps never, rightly sound. The founder of the foot is probably rheumatic, or at least often originates in a similar cause.

Mallenders are chinks or clefts behind the knees of the fore-legs; sallenders are the same defect in the hinder legs. They discharge matter, which must be treated with thorough ablution, repellents, and mercurial washes or unguents, internal alteratives or purges being also administered. Wash thoroughly with a linen rag and soap-suds warm the wound of the broken knee, in order to discharge the gravel or dirt which may have intruded. Bathe with brandy, or bind upon the part tow dipped in tincture of myrrh and brandy. In case of swelling, it may be useful to poultice, and afterwards bathe with brandy and vinegar warm. Sheet-lead bandaged on the part may make the hair grow smooth.

Lameness in the shoulder is comparatively a very rare occurrence, notwithstanding which grooms and farriers in general, from a deceptio visus, and not being skilled in a manual detection of affections of the parts, generally imagine every lameness to exist in the shoulder. In an obvious and real lameness of the shoulder, during the tension and inflammation, rowelling is necessary, with spirituous and astringent fomentations; but that which is of far the greatest consequence, sufficient time to repose at grass.

Strains in the loins and couplings.—A strengthening charge and embrocation may have some good effect; but remaining at rest abroad, for a considerable length of time, is the only cure when the case is curable.

Lameness of the hip or whirlbone, and of the stifle-bone, similar to the small cramp-bone in a leg of mutton.—In the former case the symptoms are, swinging of the limb, or its being longer than naturally: in trotting the horse droops backward upon the heel. Time and rest, with applications as above, cure a recent case of this kind; but from neglect it becomes incurable. The whirl-bone or hip, is sometimes depressed or beat down with violence, and so remains, the horse yet continuing useful. A mare in this state, thence called slip, even-raced. On lameness of the stifle, Snape says, "It is worth the dissector's taking notice of these three last muscles, how they are joined all in one, just at their crossing the stifle, where they make one broad and very strong tendon, which spreads over and involves the patella, or little bone of the stifle, and ties it so fast in its place, upon the jointing of the thigh-bone with the tibia, that it is very seldom displaced, or indeed never. For although by distensions or strains we often have this part affected, yet never did I see an absolute dislocation in it. The patella indeed may be, and often is, wrenched either to one side or the other, as the accident may happen." Cure consists in rest, and the usual treatment of strains: the tumour will sometimes, but rarely, suppurate, which is a present remedy.

Teeth and age of the horse.—The horse has forty teeth: twenty-four double teeth or grinders, four tushes or single teeth, and twelve front teeth or gatherers. Mares in general have no tushes. The black marks or cavities, which denote the age, are to be found in the corner front teeth, adjoining the tushes. Horned cattle have similar marks in the teeth. At four years and a half old, the mark-teeth are just visible above the gum, and the cavity is very conspicuous. At five, the horse sheds his remaining colt's teeth, and his tushes appear. At six, his tushes are up, and appear white, small, and sharp; near which is observable a small circle of young, growing, flesh: the horse's mouth is then complete, and the corner teeth filled up. At seven years old, the two middle teeth fill up. At eight, the black marks vanish, and the horse's mouth is said to be full, and himself aged. The French farriers aver that the marks remain in the teeth of the upper jaw until the horse is twelve years of age; but we believe this to be fortuitous.

The lampas, from the Latin lampascus, is an inflammation and tumour of the first bar of the young horse's mouth, adjoining the upper fore teeth, which prevent his chewing. If scalded mashes, warm gruel, Glauber's salts in the water, and bleeding, do not remove the inconvenience in a week, lightly cauterize the tumid parts, without penetrating deep enough to scale off the thin bone beneath the upper bars. Wash with salt and water first, afterwards heal with a mixture of honey and brandy or port wine. La Fosse and others have denied the existence of this slight malady; but we have witnessed it repeatedly. We have also seen the haw in the eye, and the probability of its obstructing the sight, with its successful excision, a very small part of the substance being extirpated; the proper rule, should excision ever be recurred to, in truth a matter of doubt, as a painful operation. The haw is a preternatural enlargement and sponginess of the caruncle, a fleshy substance in the inner corner of the eye, causing the ligament which runs along the verge of the membrane to compress the eyeball like a hoop.

Shoeing.—The veterinarian who is ambitious of being thoroughly grounded in this important branch of his art, should study attentively the principles and rules of La Fosse, Bourgelat, and Osmer, comparing them with what has been since written by Mr. Clarke, and the professors Saintbel and Coleman. One or two of the ancients have mentioned the iron shoe, but it did not probably come into general use in Europe until the fifteenth century. It has been often hinted that horses might be accustomed to labour without shoes, and that exposure to the hard ground would render their soles obdurate, a consequence which is also pretended to result from their standing upon a hard, unlittered pavement, with abundance of similar and futile sophistry. The distressing accidents which have happened from the loss of a shoe, in consequence of which, from a few hours speedy travel by night, the hoof has been worn away to the very bones of the foot, are a full and lamentable answer to such follies. Indeed, in hot and dry countries, where the hoof is na-

turally hard, and the exertions of the horse very limited, compared with those he undergoes in this country, he is perhaps generally ridden without shoes. In the Welsh mountains this is also occasionally practised: but upon our roads, particularly in wet weather and in winter, the walls, sole, and frog, would be rubbed away and totally destroyed, granting the practice was used with a young and perfect foot, which never knew the protection of a shoe; nor have we any horses but would flinch under such an exposure of their feet.

A young and perfect foot has a firm and level bearing upon the circular crust or wall, and the frog, which however is an elastic substance, and the fulcrum or rather cushion of the main tendon. The frog is yet not a solid and steady support, but springs or contracts on touching the ground. In some very concave feet, of bred cattle particularly, the frog is not of sufficient bulk to reach the ground; and in thousands of horses shod by common farriers, the case is similar, from the part being reduced by constant wear and paring, and by the improper height of the shoe-heels: yet the frog does its office, although surely not in so perfect a way. In general, the foot should be suffered to retain its natural form and substance on applying the shoe, the toe only being shortened, the walls or crust pared even, the sole, bars or binders, and frog, being left intire, bating a little trimming away of loose and decaying substance: instead of which, the common farriers pare the sole without mercy, almost extirpate the frog to make it appear neat, and cut away at every shoeing half the substance of the bars in order to open the heels, the direct way to shut them up, or narrow them; since one great use of the frog and bars is that of an interposing substance to keep the heels open and spreading. It must then be acknowledged, that some naturally tough, thick, and quick-growing soles may require paring, or they otherwise are inconvenient, and produce uneasy sensations in the horse; but this is perhaps never the case with respect to the frog, which, coming in contact with the ground, would always be thereby sufficiently reduced. As there are too many hoofs with thin and weak walls or crusts, in which it is difficult for the smith to find nail-hold, and from which by consequence scarcely an atom can be spared to the paring-knife, so there are others of the concave and deep kinds, in which the surrounding edges or crusts are so high and tough, that it is absolutely necessary and salutary to the foot to soften it by paring them down occasionally, bringing the pittance of a frog nearer to the ground, disposing it to enlarge and thereby expand the narrow and wiry heels.

A shoe should be so formed, that the horse may stand steady and firm upon his natural level, namely to bear equally upon the toe and the surrounding wall or crust; the frog, if in its perfect and natural state, touching the ground. The shoe-heels may be reduced in substance, in order to enable the frog, defective in size, to touch the ground, provided a too great tenderness and sensibility in the frog, a very common case even in a colt, do not forbid it. In that circumstance, attended by a soreness or defect in the quarters also, the shoe-heels must be of sufficient thickness to do the office of the frog, and preserve the just level of the foot; for with reduced quarters and shoe-heels, and no frog to support the tendon, the latter must suffer great distension even from the mere natural weight of the horse; and in this way, from a forced attempt at improvement of the frog, by certain speculators, great numbers of horses were instantly lamed. Our common farriers, however, have usually run into the opposite defect, and by extremely thick shoe-heels, and even the addition of chalkings to the fore-shoes, have thrown the weight of the horse chiefly upon his toes. They are doubtless much improved in their practice in most parts of England, but in some, the old dangerous and destructive form of shoe is still retained; long, broad, and convex in the external surface, and concave next the foot. Such is precisely the common shoe of the draught-horse even in the metropolis, where one would suppose common sense, in the course of more than fifty years, must have had time to operate. Yet we lately witnessed the heart-rending exertions of four noble animals to draw up Holborn-hill a most ponderous load, the stones presenting a surface of glass, to the slippery convex, or rather globular surfaces of the horse-shoes. It is impossible but these willing animals must have ineffectually wasted more than half their powers, that is to say, the strength of the four was reduced to less than that of two, by the senseless form of their shoes; and we represented to the driver, the strong probability that a quarter of an hour of such excessive exertion, might injure the horses in a greater degree, than six months of fair and regular although hard labour. Shoes should be made of the best iron well hammer-hardened, but not too much softened by the fire. Of such stuff, the shoe should be as light as the horse could bear; but it must be remembered, there must be a sufficient substance of iron in proportion to the weight of the horse, or in travelling, he will suffer from jarring or concussion of the bones of the foot. Narrowness of the web of the shoe is indubitably an advantage, but some feet require and must have more cover. The length of the shoe in general, should approach, never exceed, the extremity of the heel, and should decrease in width at the heel, excepting a need to defend weak quarters. The surface of the shoe presented to the earth should ever and without exception be flat, and even when practicable, hammered somewhat concave or hollow, which gives a firmer tread on slippery surfaces. This is a very old idea, and although professor Saintbel did not succeed in reducing it to practice with thin shoes, it can meet with no obstruction in the heavy shoes of cart-horses, which are however always made far heavier than necessary, from being forged of inferior materials, a consideration for the opulent proprietors of draught-horses. The shoe must rest entirely on the wall or crust, never on the sole, on which the pressure would occasion lameness. To this end, that part of the shoe applied to the crust must be flat, consisting of a rim or margin according in breadth, with the crust, and of equal thickness around the outside of the rim, in the middle of which exactly the nail-holes are to be made; from this margin internally, towards the sole, the shoe must be formed gradually thinner, that it may not press upon the sole. Osmer farther directed, and it has been invariably followed by the best practitioners, that the shoe should be made to stand somewhat wider at the extremity of each heel, than the foot itself; otherwise, as the foot grows in length, the heel of the shoe in a short time, gets within

BB. The blade-bone or scapula.
C. The humerus, or shoulder-bone.
DD. The bones of the leg, or fore-arm, consisting in each of the radius and ulna.
EE. The joints of the knees, with the small ranges of bones.
FF. The posterior parts of the knee-joints.
GG. The shank-bones, consisting in each of the cannon bone, and the two metacarpal, or splent-bones.
HH. The great pastern bones, with the two sesamoid bones of each fetlock.
II. The lesser pastern bones.
KK. The bones of the feet, consisting in each of the coffin and navicular bones, with the lateral cartilages.
LL. The bones of the pelvis, called ossa innominata.
MM. The thigh-bones.
NN. The bones of the hind-legs, consisting in each of the tibia and the fibula.
OO. The points of the hocks.
PP. The small bones of the hocks.
QQ. The bones of the instep; consisting in each of the cannon bone and two metatarsal bones.
RR. The great pastern and sesamoid bones of the hind-legs.
SS. The little pastern bones of the hind-legs.
TT. The coffin and navicular bones of each hind-foot, with the lateral cartilages.
V. The sternum, or breast-bone.
X. The point of the sternum.
YY. The ribs.
Z. The cartilaginous ends of the ribs on the breast and abdomen.
I. II. III. IV. V. VI. VII. The seven vertebræ of the neck.
1. 2. 3. 4. 5. 6. 7. 8. 9. 10, 11. 12. 13. 14. 15. 16. 17. 18. The eighteen vertebræ of the thorax and back.
1. 2. 3. 4. 5. 6. The six vertebræ of the loins.
1. 2. 3. 4. 5. The five spines of the os sacrum.
1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. The eighteen joints of coxendix and tail.

Figure 2.—Representing the intestines of a horse as they appear in their natural situation when the abdomen is laid open.
AAAAAA. The colon, with its various circumvolutions and windings, together with its numerous folds, and under which lie the small intestines.
B. The cœcum, or blind gut.
C. The rectum.

Figure 3.—Shows the horny sole *a* raised from the fleshy sole *c c c;* round which is the enchannelled flesh *y*, placed in the falcus of the inner surface of the hoof, the horny part of which is soft and white.

Figure 4.—Represents the under part of the fleshy sole *c*, raised from the foot-bone, or coffin-bone, *d d d; g* the covering or sheath of the tendo Achillis; *z* the cartilage; *y* the edge of the fleshy sole confined in the furrow of the channelled horny substance.

Figures 5 and 6.—Give the bottom or base of the foot; *a a a* the horny sole; *b* the frog; *z* the hoof towards its lower edge, called the crust or wall of the foot.

Figures 7 and 8.—Modern shoes.

FARTHING *of gold*, a coin used in ancient times, containing in value the fourth part of a noble, or 20*d.* silver. It is mentioned in the stat. 9 Hen. V. cap. 7. where it is enacted, that there shall be good and just weight of the noble, half-noble, and farthing of gold.

Farthing *of land*, seems to differ from Farding-*deal;* for in a survey-book of the manor of West-Hapton, in Devonshire, there is an entry thus: A. B. holds six farthings of land at 126*l.* per ann. So that the farthing of land must have been a considerable quantity, far more than a rood.

FASCES, in Roman antiquity, axes bound up together with rods or staves, and carried before the Roman magistrates as a badge of their authority and office. The use of the fasces was introduced by the elder Tarquin, as a mark of sovereign authority: in aftertimes they were borne before the consuls, but by turns only, each his day. They had twelve of them carried by so many lictors. After the consuls, the prætors assumed them, and Censorinus observes they had only two, though Plutarch and Polybius give them six. In the government of the decemviri, it was the practice at first for only two of them to have the fasces. Afterwards each of them had twelve, in the same manner as the kings.

FASCETS, in the art of making glass, are the irons thrust into the mouths of bottles, in order to convey them into the annealing tower.

FASCIÆ, in astronomy, certain parts on Jupiter's body resembling belts or swaths. They are more lucid than the rest of that planet, and are terminated by parallel lines, sometimes broader, and sometimes narrower. Mr. Huygens observed a facia in Mars much broader than those in Jupiter, and possessing the middle part of his disk, but very obscure.

FASCINES, in fortification, faggots of small wood of about a foot diameter, and six feet long, bound in the middle, and at both ends. See Fortification.

FASCIOLA, in zoology, the fluke or gourd worm: a genus of insects of the order of vermes intestina; of which the characters are these: The body is flattish, and has a vent-hole at the extremity and on the belly. There are several species. 1. The hepatica, or liver-fluke, grows to two-thirds of an inch in length, though it is more usually met with not half that size; and its breadth is nearly equal to two-thirds of its length. It is flattish, but somewhat rounded on the back, and has about eight deep longitudinal furrows in two series; its skin is soft and whitish, with a tinge of brown. The hinder part is rounded, the fore part is furnished with a large mouth. It bears some resemblance to the seed of the common gourd, whence it has acquired the name of the gourd worm. It is found in fresh waters, in ditches, at the roots of stones, sometimes in the intestines, and often in the substance of the other viscera in quadrupeds. It often infests the liver of sheep, and on that account is called hepatica. Bags with salt in them should be placed in the fold, that sheep might lick them, which is a good remedy. 2. The intestinalis, or intestinal fluke, is of a long slender form, if extended; when contracted, of a suboval form; inhabits the intestines of fresh-water fish, especially the bream. 3. The barbata, is white, with transverse papillæ in the mouth. It is of an oblong shape, and about the size of a cucumber-seed.

FASHION-PIECES, in the sea language, are two

compassing pieces of timber, into each side of which is fixed the transom.

FASTERMANS, among our Saxon ancestors, were pledges or bondsmen, who were answerable for each other's good behaviour.

FASTI, in Roman antiquity, the calendar wherein were expressed the several days of the year, with their feasts, games, and other ceremonies. There were two sorts of fasti, the greater and less; the former being distinguished by the appellation of fasti magistrales, and the later by that of fasti calendares. The greater fasti contained the feasts, with every thing relating to religion and the magistrates. The lesser were again distinguished into the city and country fasti, each adapted to the people for whom they were designed. In all these fasti, the court-days, or those whereon causes might be heard and determined, were marked with the letter F; these days were called fasti, from fari, to speak or pronounce; and the other days, not marked with this letter, were called nefasti.

FASTI CONSULARES, was also a tablet, or chronicle, wherein the several years were denoted by the respective consuls, with the principal events that happened during their counsulship. And hence, the term fasti is still applied to the archives and public registers of a nation.

FAT, in anatomy, an oleaginous or buty-raceous matter, secreted from the blood, and filling up the cavity of the adipose cells.

FAT, in chemistry. See OIL.

FAT, in the sea-language, signifies the same with broad. Thus a ship is said to have a fat quarter, if the trussing in or tuck of her quarter is deep.

FAT, perhaps properly vat (vas or vessel), denotes likewise an uncertain measure of capacity. Thus a fat of isinglass contains from $3\frac{1}{4}$ hundred weight to four hundred weight; a fat of unbound books, half a maund, or four bales; of wire, from 20 to 25 hundred weight; and of yarn, from 220 to 221 bundles.

FATA MORGANA, a very remarkable aerial phenomenon, which is sometimes observed from the harbour of Messina and adjacent places, at a certain height in the atmosphere. The name, which signifies the Fairy Morgana, is derived from an opinion of the superstitious Sicilians, that the whole spectacle is produced by fairies, or such-like visionary invisible beings. The populace are delighted whenever it appears; and run about the streets shouting for joy, calling every body out to partake of the glorious sight.

This singular meteor has been described by various authors; but the first who mentioned it with any degree of precision was father Angelucci, whose account is thus quoted by Mr. Swinburne in his Tour through Sicily: "On the 15th of August, 1643, as I stood at my window, I was surprised with a most wonderful delectable vision. The sea that washes the Sicilian shore swelled up, and became, for ten miles in length, like a chain of dark mountains; while the waters near our Calabrian coast grew quite smooth, and in an instant appeared as one clear polished mirror, reclining against the ridge. On this glass was depicted, in chiaro-scuro, a string of several thousand of pilasters, all equal in altitude, distance, and degree of light and shade. In a moment they lost half their height, and bent into arcades, like Roman aqueducts. A long cornice was next formed on the top, and above it rose castles innumerable, all perfectly alike. These soon split into towers, which were shortly after lost in colonnades, then windows, and at last ended in pines, cypresses, and other trees, even and similar. This is the Fata Morgana, which for twenty-six years I had thought a mere fable."

To produce this pleasing deception, many circumstances must concur, which are not known to exist in any other situation. The spectator must stand with his back to the east, in some elevated place behind the city, that he may command a view of the whole bay; beyond which the mountains of Messina rise like a wall, and darken the back-ground on the picture. The winds must be hushed, the surface quite smooth, the tide at its height, and the waters pressed up by currents to a great elevation in the middle of the channel. All these events coinciding, as soon as the sun surmounts the eastern hills behind Reggio, and rises high enough to form an angle of 45 degrees on the water before the city, every object existing or moving at Reggio will be repeated a thousandfold upon this marine looking-glass; which, by its tremulous motion, is in a manner cut into facets. Each image will pass rapidly off in succession as the day advances, and the stream carries down the wave on which it appeared. Thus the parts of this moving picture will vanish in the twinkling of an eye. Sometimes the air is at that moment so impregnated with vapours, and undisturbed by winds, as to reflect objects in a kind of aerial screen, rising about 30 feet above the level of the sea. In cloudy heavy weather they are drawn on the surface of the water, bordered with fine prismatical colours.

To the above account we shall add the following, by another observer: "In fine summer days, when the weather is calm, there rises above the great current a vapour, which acquires a certain density, so as to form in the atmosphere horizontal prisms, whose sides are disposed in such a manner, that when they come to their proper degree of perfection, they reflect and represent successively, for some time, (like a moveable mirror) the objects on the coast or in the adjacent country. They exhibit by turns the city and suburbs of Messina, trees, animals, men, and mountains. They are certainly beautiful aerial moving pictures. There are sometimes two or three prisms, equally perfect; and they continue in this state eight or ten minutes. After this some shining inequalities are observed upon the surface of the prism, which render confused to the eye the objects which had been before so accurately delineated, and the picture vanishes. The vapour forms other combinations, and is dispersed in air. Different accounts have been given of this singular appearance; which for my part I attribute to a bitumen that issues from certain rocks at the bottom of the sea, and which is often seen to cover a part of its surface in the canal of Messina. The subtile parts of this bitumen being attenuated, combined, and exhaled with the aqueous globules that are raised by the air, and formed into bodies of vapour, give to this condensed vapour more consistence; and contribute, by their smooth and polished particles, to the formation of a kind of aerial crystals, which receives the light, reflects it to the eye, and transmits to it all the luminous points which

colour the objects exhibited in this phenomenon, and render them visible."

FATHER, in church history, is applied to ancient authors who have preserved in their writings the traditions of the church. Thus St. Chrysostom, St. Basil, &c. are called Greek fathers, and St. Augustine and St. Ambrose Latin fathers. No author who wrote later than the twelfth century is dignified with the title of Father.

FATHER AND SON. In law the father shall not have action for taking any of his children, except his heir; and that is, because the marriage of his heir belongs to the father, but not of any other of his sons or daughters. And the father has no property or interest in the other children, which the law accounts may be taken from him. Cro. Eliz. 770.

The father is obliged by the common law to provide for his children. Lord Raym. 41.

Justices cannot order a maintenance for a child to be paid by the father, without adjudging that the child is poor, or likely to become chargeable. Id. 669.

FATHOM, a long measure containing six feet, chiefly used at sea for measuring the length of cables and cordage.

FAVORITO, in music, as choro favorito, a chorus in which are employed the best voices and instruments, to sing the recitatives, play the ritornellas, &c.; this is otherwise called the little chorus, or choro recitante.

FAUSSE-BRAYE, in fortification, a small rampart without the true one, about three or four fathom wide, and bordered with a parapet and banquet. SEE FORTIFICATION.

FEAL-DIKES, a cheap sort of fence common in Scotland, built with feal or sod dug up by the spade from the surface of grass-ground, consisting of the upper mould rendered tough and coherent by the matted roots of the grass thickly interwoven with it. If only a very thin bit of the upper surface is pared off with a paring-spade, the pieces are called divots. These being of a firmer consistence, are more durable when built into dikes than feal, but much more expensive also.

FEALTY, in law, an oath taken on the admittance of any tenant, to be true to the lord of whom he holds his land; by this oath the tenant holds in the freest manner, on account, that all who have fee, hold per fidem et fiduciam, that is, by fealty at the least. This fealty, at the first creation of it, bound the tenant to fidelity, the breach of which was the loss of his fee. It has been divided into general and special; general, that which is to be performed by every subject to his prince; and special, required only of such as, in respect of their fee, are tied by oath to their lords. To all manner of tenures, except tenantcy at will and frank-almoign, fealty is incident, though it chiefly belongs to copyhold estates, held in fee and for life. The form of this oath by stat. 17 Ed. II. is to run as follows. "I, A. B. will be to you my lord D. true and faithful, and bear to you faith for the lands and tenements which I hold of you, and I will truly do and perform the customs and services that I ought to do to you. So help me God."

FEAST, or FESTIVAL, in a religious sense, is a day of feasting and thanksgiving.

The four quarterly feasts, or stated times whereon rent on leases is usually reserved to be paid, are Lady-day, or the annunciation of the blessed virgin Mary, or 25th of March; the nativity of St. John the Baptist, held on the 24th of June, the feast of St. Michael the archangel, on the 29th of September; and Christmas, or rather St. Thomas the apostle, on the 21st of December.

FEATHER, in physiology, a general name for the covering of birds: it being common to all the animals of this class to have their whole body, or at least the greatest part of it, covered with feathers or plumage.

There are two sorts of feathers found on birds, viz. the strong and hard kind, called quills, found on the wings and tail; and the other plumage, or soft feathers, serving for the defence and ornament of the whole body. All birds, so far as yet known, moult the feathers of their whole body yearly. Feathers make a considerable article of commerce, particularly those of the ostrich, heron, swan, peacock, goose, &c. for plumes, ornaments of the head, filling of beds, writing-pens, &c. Geese are plucked in some parts of Great Britain five times in the year; and in cold seasons many of them die by this barbarous custom. Those feathers that are brought from Somersetshire are esteemed the best, and those from Ireland the worst.

Eider down is imported from Denmark; the ducks that supply it being inhabitants of Hudson's-bay, Greenland, Iceland, and Norway. All the islands west of Scotland breed numbers of these birds, which turn out a profitable branch of trade to the poor inhabitants. Hudson's-bay also furnishes very fine feathers, supposed to be of the goose kind. The down of the swan is brought from Dantzic. The same place also sends us great quantities of the feathers of the cock and hen. The London poulterers sell a great quantity of the feathers of those birds, and of ducks and turkeys; those of ducks, being a weaker feather, ar inferior to those of the goose; and turkey's feathers are the worst of any. The best method of curing feathers is to lay them in a room, exposed to the air and sun; and when dried, to put them in bags, and beat them well with poles to get off the dirt.

Feathers, when chemically analysed, seem to possess very nearly the same properties with hair. According to Mr. Hatchett, the quill is composed chiefly of coagulated albumen, without any traces of gelatine. See HAIR.

FEATHER-MILL, in the salt-works, the partition in the middle of the furnace, which it divides into two chambers. See the article SALT-MAKING.

FEATHER-EDGED, among carpenters, an appellation given to planks or boards which have one side thicker than the other.

FECIALES, or FÆCIALES, a college of priests instituted at Rome by Numa, consisting of twenty persons, selected out of the best families. Their business was to be arbitrators of all matters relating to war and peace, and to be the guardians of the public faith. It is probable that they were ranked among the officers of religion, to procure them the more deference and authority, and to render their persons more sacred among the people. If the commonwealth had received any injury from a foreign state, they immediately despatched these officers to demand satisfaction, who, if they could not procure it, were to attest the Gods against the people and country,

and to denounce war: otherwise they confirmed the alliance, or contracted a new one, which they ratified by sacrificing a hog.

FECULA. See GLUTEN.

FEE, in law. All lands in England (the crown-land being in the king's own hands, in right of his crown, excepted) is in the nature of feudum or fee; for though many have land by descent from their ancestors, and others have clearly purchased land with their money, yet is the land of such a nature, that it cannot come to any, either by descent or purchase, but with the burthen that was laid upon him who had novel fee, or first of all received it as a benefit from his lord to him, and to all such to whom it might descend, or any way be conveyed from him; so that in truth, no man has directum dominium, the very property or demesne, in any land, but only the prince in right of his crown. Cam. Brit. 93. See FEODAL SYSTEM.

FEE SIMPLE, is an estate of inheritance whereby a person is seised of lands, tenements, or hereditaments, to hold to him and his heirs for ever, generally, absolutely, and entirely; without mentioning what heirs, but referring that to his own pleasure, or the disposition of the law. It is the most perfect tenure of any, when unincumbered; but although the greatest interest which by our law a subject can possess, yet it may be forfeited for treason or felony. To constitute an estate in fee, or of inheritance, the word heir is necessary in the grant or donation. Co. Lit. 1. Plowd. 498. 2 Black. 48.

FEE QUALIFIED, is such a freehold estate, as has a qualification subjoined to it, and which therefore must determine whenever the qualification is at an end. Co. Lit. 27.

FEE CONDITIONAL. This estate was, at the common law, a fee restrained to some particular heirs, exclusive of others; as to the heirs of a man's body, or to the heirs male of his body: in which cases it was held, that as soon as the grantee had issue born, the estate was thereby converted into fee simple, at least so far as to enable him to sell it, to forfeit it by treason, or to charge it with incumbrances. But the statute de donis having enacted, that such estates so given, to a man and the heirs of his body, should at all events go to the issue, if there were any, or if none, should revert to the donor; this was by the judges denominated an estate in tail. Plowd. 251. See ESTATE.

FEE also signifies a certain allowance to physicians, barristers, attorneys, and other officers, as a reward for their pains and labour. If a person refuse to pay an officer his due fees, the court will grant an attachment against him, to be committed till the fees are paid; and an attorney may bring an action on the case for his fees, against the client that retained him in his cause.

FEE also denotes a settled perquisite of public officers, payable by those who employ them. The fees due to the officers of the custom-house, are expressly mentioned in a schedule, or table, which is hung up in public view in the said office, and in all other places where the said fees are to be paid or received. And if any officer shall offend, by acting contrary to the regulations therein contained, he shall forfeit his office and place, and be for ever after incapable of any office in the custom-house. The other public officers have likewise their settled fees, for the several branches of business transacted in them.

FEE FARM, is when the lord, upon the creation of the tenantcy, reserves to himself and his heirs, either the rent for which it was before let to farm, or at least a fourth part of that farm rent.

FEE FARM RENT, so called, because a farm rent is reserved upon a grant in fee.

FEELERS, in natural history, a name used by some for the horns of insects. See ENTOMOLOGY.

FEELING, one of the five external senses, by which we obtain the ideas of solid, hard, soft, rough, hot, cold, wet, dry, and other tangible qualities.

This sense is the coarsest; but at the same time the surest of all others; it is besides the most universal. We see and hear with small portions of our body, but we feel with all. Nature has bestowed that general sensation wherever there are nerves, and they are every where, where there is life. Was it otherwise, the parts divested of it might be destroyed without our knowledge. It seems on this account nature has provided, that this sensation should not require a particular organization. The structure of the nervous papillæ is not absolutely necessary to it. The lips of a fresh wound, the periosteum, and the tendons, when uncovered, are extremely sensible without them. These nervous extremities serve only to the perfection of feeling, and to diversify sensation. Feeling is the basis of all other sensations.

The object of feeling is every body that has consistency or solidity enough to move the surface of our skin. It was necessary to perfect feeling, that the nerves should form small eminences, because they are more easily moved by the impression of bodies, than an uniform surface. It is by means of this structure, that we are enabled to distinguish not only the size and figure of bodies, their hardness and softness, but also there heat and cold. Feeling is so useful a sensation, that to the blind it supplies the office of eyes, and in some sense indemnifies them for their loss. See PHYSIOLOGY.

FEIGNED ISSUE, is that whereby an action is feigned to be brought by consent of the parties, to determine some disputed right, without the formality of pleading; and thereby to save much time and expense in the decision of a cause. 3 Black. 452.

FELAPTON, in logic, one of the six moods of the third figure of syllogisms, wherein the first proposition is an universal negative, the second an universal affirmative, and the third a particular negative.

FELIS, *cat*, in zoology, a genus of the mammalia class, belonging to the order of feræ. The generic character is: front-teeth six, the intermediate ones equal; grinders three on each side; tongue aculeated backwards; claws retractile.

1. Felis leo, lion. The lion is principally an inhabitant of Africa, but is also found, though far less plentifully, in the hotter regions of Asia. It is, however, in the interior of Africa that he exerts his greatest ravages, and reigns superior among the weaker quadrupeds. A lion of the largest size has been found to measure about eight feet from the nose to the tail, and the tail itself about four feet; the general colour is a pale tawny, still paler or more inclining to white beneath; the head is

very large, the ears rounded, the face covered with short or close hair, the upper part of the head, the neck, and shoulders, coated with long shaggy hair, forming a pendent mane; on the body the hair is short and smooth; the tail is terminated by a tuft of blackish hair. The lioness, which is smaller than the lion, is destitute of the mane, is of a whiter cast beneath. The lion, like the tiger, frequently conceals himself in order to spring on his prey, bounding to the distance of a great many feet, and seizing it with his claws. His strength is prodigious: it has even been affirmed, that a single stroke of his paw is sufficient to break the back of a horse; and that he carries off with ease a middle-sized ox or buffalo. He does not often prey in open sunshine, but commences his depredations at the close of day. The roaring of the lion, when in quest of prey, resembles the sound of distant thunder; and, being re-echoed by the rocks and mountains, appals the whole race of animals, and puts them to sudden flight; but he frequently varies his voice into a hideous scream or yell: he is supposed to be destitute of a fine scent, and to hunt by the eye alone. The lion is commonly said to devour as much as will serve him for two or three days, and when satiated with food, to remain in a state of retirement in his den, which he seldom leaves, except for the purpose of prowling about for his prey. His teeth are so strong, that he breaks the bones with perfect ease, and often swallows them together with the flesh; his tongue, as in other animals of this genus, is furnished with reversed prickles; but they are so large and strong in the lion, as to be capable of lacerating the skin. The lioness is said to bring forth in the spring, in the most sequestered places, and to produce but one brood in the year. The young are four or five in number, which the parent nurses with great assiduity, and attends in their first excursions for prey. When brought into Europe, lions have been known to breed even in a state of confinement; instances of which are recorded by some of the older naturalists. In the Tower of London also, examples of a similar nature have occurred. The young animals are scarcely so large as small pug dogs, and are said to continue at the teat about the space of a year, and to be five years in coming to maturity. If we may judge from some specimens of young lions in the Leverian Museum, which are said to have been whelped in the Tower, their size seems scarcely to exceed that of a half-grown kitten. Indeed, some of the ancient writers have affirmed, that the young lions are hardly larger than weasels.

The count de Buffon, reasoning from the size and constitution of the lion, and the time required for his arriving at full growth, concludes that he "ought to live about seven times three or four years, or nearly to the age of twenty-five." He adds, that those which have been kept at Paris have lived sixteen or seventeen years. If, however, we might depend on the commonly received accounts of those which have been kept in the Tower of London, we might mention the lion known by the name of Pompey, which is said to have lived no less than 70 years in his state of captivity; and another in the same receptacle, which is reported to have lived 63 years. It must be acknowledged, however, that, from the general constitution of the lion, one would not suppose him to be a very long-lived animal.

Lions have sometimes constituted a part of th esta-blished pomp of royalty in the eastern world. The monarch of Persia, as we are informed by Mr. Bell, in his Travels, had, on days of audience, two large lions chained on each side the passages of the hall of state, being led thither, by proper officers, in chains of gold.

The Romans, struck with the magnificent appearance of these animals, imported them in vast numbers from Africa, for their public spectacles. Quintus Scævola, according to Pliny, was the first in Rome who exhibited a combat of lions; but Sylla the dictator, during his prætorship, exhibited a hundred lions; and after him Pompey the Great exhibited no less than 600 in the grand circus, viz. 315 males, and the rest females; and Cæsar the dictator 400. Pliny also tells us, that the first person in Rome who caused them to be yoked so as to draw a carriage, was Mark Antony, who appeared in the streets in Rome in a chariot drawn by lions, accompanied by his mistress Cytheris, an actress from the theatre; a sight says Pliny, that surpassed in enormity even all the calamities of the times!

In modern times, the lion is said to be often hunted with dogs by the colonists about the Cape of Good Hope, and it is added that twelve or fifteen dogs are sufficient for the purpose. The lion, after being roused, runs for same time, then stops and shakes his mane, as if in defiance of the dogs, who, rushing all at once upon him, soon destroy him; two or three of the pack, however, generally falling victims to the first strokes of his paws. See Plate LVII. Nat. Hist. fig. 200 & 201.

2. Felis tigris, tiger, is a native of the warmer parts of Asia, and is principally found in India and the Indian islands. The species extends, however, as far as China and Chinese Tartary, the lake Ural, and the Altaic mountains. Its colour is a deep tawny, or orange-yellow, the face, throat, and under side of the belly, being nearly white; the whole is traversed by numerous long black stripes, forming a bold and striking contrast with the ground-colour. About the face and breast the stripes are proportionally smaller than on other parts; the tail is annulated with black, and is shorter than the body. There seems to be some variation in the proportion and number of the stripes in different individuals; and the ground-colour is more or less bright, according to various circumstances of age and health in the respective animals. Linnæus calls the tiger "*pulcherrimus quadrupedum*." We must not judge of the elegance of this animal's robe from the specimens which are sometimes seen in museums, or even from such living ones as by long confinement, and an alteration of climate, have lost the native brilliancy of their colours. When seen in perfection, and before its health has been impaired by confinement, it is scarcely possible to conceive a more elegantly variegated animal than the tiger: the bright and intense orange-yellow which constitutes the ground colour; the deep and well-defined stripes of black, in some parts double, in others single; the pure white of the cheeks and lower part of the sides, over which a part of the black striping is continued; form all together an appearance far superior in beauty to the skin of the zebra, or that of any other regularly marked quadruped, not excepting even the panther itself.

In its general size the tiger is inferior only to the lion, and has been seen even larger, viz. of the length

of 15 feet from the nose to the tip of the tail. The largest are those of India, and are termed royal tigers; but this distinction is supposed to relate merely to the size of the animal, there being only one species of tiger, though there may perhaps be some races larger than others.

Of so fierce and sanguinary a disposition is the tiger, as to surpass in rapacity every other wild beast, and it is therefore considered as the most dreadful scourge of the hotter regions of Asia. The lion is commonly supposed to prey in a less malignant and cruel manner. He is also, when taken into a state of confinement, capable of being tamed, and rendered mild and placid to his keepers; but the tiger is not to be divested of his natural ferocity of character, and in confinement he generally exhibits all the symptoms of malignity. His method of seizing his prey is by concealing himself from view, and springing with a horrible roar on his victim, which he carries off and tears in pieces, after having first sucked out the blood. The voice of the tiger, in the act of springing on his prey, is said to be hideous beyond conception. Even a buffalo has been thus seized by a tiger, and carried off with as much seeming ease, as to appear scarcely an impediment to the animal's flight. It is affirmed, that if the tiger happens to miss his aim, he does not pursue his prey, but, as if ashamed of his disappointment, runs off. In the beginning of the last century (says Mr. Pennant), a company, seated under the shade of some trees near the banks of a river in Bengal, were surprised by the unexpected sight of a tiger preparing for its fatal spring; when a lady, with almost unexampled presence of mind, furled a large umbrella in the animal's face, which instantly retired, and thus gave an opportunity of escaping from so terrible a neighbour. Another party had not the same good fortune; but in the height of their entertainment lost in an instant one of their companions, who was seized and carried off by a tiger. But the fatal accident which occurred in 1792, in the East Indies, must be still fresh in the memory of all who have read the dreadful description given by an eye-witness of the scene. "We went (says the narrator) on shore on Sangar island to shoot deer, of which we saw innumerable traces, as well as of tigers; notwithstanding which we continued our diversion till near three o'clock, when, sitting down by the side of a jungle to refresh ourselves, a roar like thunder was heard, and an immense tiger seized on our unfortunate friend Mr. Monro, son of sir Hector Monro, and rushed again into the jungle, dragging him through the thickest bushes and trees, every thing giving way to his monstrous strength: a tigress accompanied his progress. The united agonies of horror, regret, and fear, rushed at once upon us. I fired on the tiger: he seemed agitated. My companion fired also; and in a few moments after this, our unfortunate friend came up to us, bathed in blood. Every medical assistance was vain, and he expired in the space of 24 hours, having received such deep wounds from the teeth and claws of the animal as rendered his recovery hopeless. A large fire, consisting of 10 or 12 whole trees, was blazing by us at the time this accident took place, and ten or more of the natives were with us. The human mind can scarcely form any idea of this scene of horror. We had hardly pushed our boat from that accursed shore, when the tigress made her appearance, almost raging mad, and remained on the sand all the while we continued in sight."

The tiger has been known to attack even a lion, and both animals have perished in the conflict. The tigress, like the lioness, produces four or five young at a litter: she is at all times furious, but her rage rises to the utmost extremity when robbed of her young. She then braves every danger, and pursues her plunderers, who are often obliged to release one in order to retard her motion. She stops, takes it up, and carries it to the nearest cover, but instantly returns, and renews her pursuit, even to the very gates of buildings or the edge of the sea; and when her hope of recovering them is lost, she expresses her agony by hideous howlings, which excite terror wherever they reach. See Plate LX. Nat. Hist. fig. 204.

3. Felis pardus, panther. Next to the tiger, the panther is the most conspicuous species in this genus, measuring about six feet and a half, and sometimes nearly seven feet from nose to tail, which is itself about three feet long. The colour of the panther is a bright and beautiful tawny yellow, thickly marked all over the upper parts of the body, shoulders, and thighs, with roundish black spots, disposed into circles, consisting of four or five separate spots; and there is commonly, but not always, a central spot in each circle, in which particular, as well as in its superior size and deeper colour, the panther differs from the leopard, which has very rarely any central spots in its circular markings. On the face and legs the spots are single, and along the top of the back is a row of oblong spots, which are still longer as they approach the tail. The breast and belly are white; the former marked with transverse dusky stripes, the latter and the tail with large irregular black spots.

The panther is principally found in Africa, and is to that country what the tiger is to Asia, with this alleviating circumstance, that it is supposed to prefer the destruction of other animals to that of man. Its manner of seizing its prey resembles that of the tiger, lurking near the sides of woods, &c. and darting forward with a sudden spring. It is of a highly ferocious nature, and scarcely to be tamed. These animals and the leopard were the varii and pardi of the ancients; and one would think (says Mr. Pennant) that the Romans would have exhausted the deserts of Africa by the numbers they drew thence for their public spectacles. Scaurus exhibited at one time 150 panthers; Pompey the Great, 410; and Augustus, 420. It has been doubted whether the panther and the leopard were natives of America as well as of the old continent; but this question seems now to be decided in the negative.

4. Felis leopardus, the leopard, is best distinguished from the panther by its paler yellow colour, its smaller size, and the somewhat closer disposition of the spots which form its ocellated markings; but to a mere general observer, the two animals are so extremely alike as to be frequently mistaken for each other. A true distinctive mark between the leopard and panther is by no means easy to communicate either by description or even by figure. The principal difference is in size, the leopard being considerably the smallest of the two: the colour of the panther is richer or more fulvous than that

of the leopard; but this too is liable to a degree of uncertainty: the ocelli or rounded marks on the panther are larger and more distinctly formed; but the character given by Mr. Pennant of the panther, viz. a central spot in the middle of each, is by no means a permanent or truly distinctive mark; since the spots in some specimens (perhaps the males) are quite plain in the middle; while, in some specimens of the leopard, one or more central spots are visible. As to the subtransverse marks about the neck or breast, they seem to be full as distinct in the leopard at in the panther, and perhaps, upon the whole, we must be content with distinguishing the two species by the size, and by the fulvous yellow of the panther, and the clearer or paler yellow of the leopard. The general length of this species from nose to tail, is four feet, of the tail two and a half. It is a native of Senegal and Guinea, as well as of many other parts of Africa: it also occurs in several parts of Asia, viz. in Persia, India, China, &c. In its manners it resembles the panther.

A variety of this species, of a dusky black, marked with spots of a deeper or more glossy black, and perfectly resembling in disposition those of the common leopard, is found in Bengal. In one of this kind taken to England some years ago, the fur, when a little turned aside, exhibited a slight tinge of the natural or general colour.

5. Felis jubata, the hunting leopard, is about the size of a large greyhound, and of a long make, with narrow chest, and long legs. It is a native of India, where it is said to be tamed, and used for the chase of antelopes and other animals; being carried into the field chained and hooded, and at the proper time loosed; when it is said to steal along the ground at first, concealing itself till it gains a proper advantage, and then to dart on the animal it pursues with several repeated springs. If it happens to miss its prey, it returns to the call of its master.

6. Felis uncia, the ounce, is scarcely inferior in size to the leopard. Its colour is dull white, with a slight yellowish or tawney cast, and the whole is scattered over with differently-sized spots and markings of black. About the head these spots are small, numerous, and roundish; along the back they form a kind of abrupt or irregularly interrupted stripes, while on the sides and limbs they are variously shaped, forming in some places angular and in others somewhat round or oval marks, with a central space included, and on the legs and tail they are black and scattered. In its general form the animal seems much allied to the leopard. It seems not to have been distinctly described by any modern author till the time of Buffon; but it is supposed to have been known to the ancients, and to have been the smaller panther of Oppian, and the panthera of Pliny. It is a native of several parts of Africa and Asia.

7. Felis onca, the Brasilian tiger, is a native of the hotter parts of South America, and is considered as a very fierce and destructive animal. Its manners are said to resemble those of the tiger, lying in ambush for its prey. See Plate LV. Nat. Hist. fig. 198. It is about the size of a wolf, or even larger. Its ground-colour is a pale brownish-yellow, variegated on the upper parts with streaks and open oblong spots or markings of black, the top of the back being marked with long interrupted stripes, and the sides with rows of regular open marks; the thighs and legs are also variegated with black spots, but without central spaces; the breast and belly are whitish; the tail not so long as the body; the upper part marked with large black spots in an irregular manner, the lower with smaller spots.

8. Felis pardalis, ocelot. The ocelot or pardalis is certainly one of the most beautiful of the present genus. In size it is almost equal to the jaguar. Mr. Pennant describes it as about four times the size of a large cat. The ground-colour of the male is a bright reddish-tawny above, nearly white on the lower part of the sides, breast, limbs, and belly. Several large, long, and variously inflected broad stripes, of a deeper or richer tinge than the ground-colour, are disposed over the upper parts of the body: these stripes are edged with black, and have also several differently-shaped black spots in the middle part. The head is streaked and spotted with black, and the upper as well as under parts of the limbs and the belly marked in a beautiful manner with small and numerous round spots; the tail is patched or spotted also. The colours of the female are less vivid, and more inclining to ash-colour. This is an extremely ferocious animal, and inhabits the hotter parts of South America, where it is said to commit great ravages among cattle, &c. It is also said to be untameable in a state of captivity. See Plate Nat. Hist. fig. 203.

9. Felis puma. The puma is the largest of the American beasts of prey, measuring five feet or more from nose to tail, the tail itself about two feet eight inches. It is a long-bodied animal, and stands high on its legs. Its colour is a pale brownish-red, with a slight dusky cast on some parts; the chin is white; the breast and belly ash-coloured; and the insides of the legs are of the same colour; the tail of a dusky-ferruginous tinge, with a black tip. It is a native of many parts of America, both north and south, occurring from Canada to Brasil. The puma is an animal of great strength and fierceness, preying on cattle, deer, &c. Sometimes it is said to climb trees, and watch the opportunity of springing on such animals as happen to pass beneath.

10. Felis discolor, black tiger. This, like the former species, is a native of America, and is considered as a very destructive and ferocious animal. It is about the size of a large dog, and is entirely of a deep brownish-black colour on the upper parts, and pale-grey or whitish beneath; the upper lip and the paws are also whitish; the tail is of the same colour with the body. See Plate Nat. Hist. fig. 205.

11. Felis tigrina, margay. The margay is a native of South America, and is about the size of a common cat. The ground-colour is a bright tawny; the face striped downwards with black; the shoulders and body marked both with stripes and large oblong black spots; on the legs the spots are small; the breast, belly, and insides of the limbs, are whitish; the tail is long, and marked with black, grey, and fulvous. It resides principally on trees, preying on birds: it is said to breed in the hollows of trees, and to bring but two young at a birth. It is very fierce and untamable.

12. Felis capensis, the Cape cat, inhabits the neighbourhood of the Cape of Good Hope, and is described

in the Philosophical Transactions, vol. 71, by Dr. Forster. In its manner it seems extremely to resemble the common cat, frequenting trees, and preying on the smaller animals. The specimen described by Dr. Forster was not more than nine months old, and had been taken quite young. It was perfectly tame and gentle, and had all the actions and manners of a domestic cat. Dr. Forster imagines it to be the same species with the 'nnussi described by Labat, who calls it a sort of wild cat of the size of a dog, with a coat striped and varied like that of a tiger. The length of a skin measured by Mr. Pennant was near three feet from nose to tail; but Dr. Forster's specimen seems to have been much smaller.

13. Felis manul. This species inhabits the middle part of northern Asia, and was first described by Dr. Pallas. It is of the size of a fox, and is of a strong and robust make. Its colour is tawny, but the crown of the head is speckled with black, and the cheeks are marked by two dusky lines running obliquely from the eyes; the feet are striped obscurely with dark lines; the tail is longer than that of a domestic cat, and is thickly beset with hair, and encircled with ten black rings, of which the three next to the tip are placed so near as almost to touch each other.

14. Felis catus. The cat, in a state of natural wildness, and from which are supposed to have proceeded all the varieties of the domestic cat, is a native of the northern regions of Europe and Asia. In this its natural state it differs in some slight particulars from the domestic animal, having a somewhat shorter tail in proportion, a flatter and larger head, and stronger limbs; and, from an exact anatomical inspection of its inferior parts, it appears that the intestines are somewhat shorter than those of the domestic cat. The colour of the wild cat is commonly a pale yellowish-grey, with dusky stripes and variegations, those on the back running lengthwise, those on the sides transversely and with a curved direction: the tail is annulated with several alternate circles of blackish-brown and dull white; the tip of the nose and the lips are black. Even wild cats, however, appear to differ in their shades of colour in different parts of Europe. Mr. Schreber, in his plate of quadrupeds, figures a specimen of a pretty deep tawny colour, varied with black or deep-brown streaks, so that the animal has very much the appearance of a tiger in miniature; while on another plate he has exhibited one, communicated by Dr. Pallas, of a pale grey with black or dark-brown variegations.

The manners of the wild cat resemble those of the lynx, and several others of this genus, living in woods, and preying on young hares, on birds, and a variety of other animals, which it seizes by surprise. It breeds in the hollo s of trees, and produces about four at a birth. "The wild cat (says Mr. Pennant) may be called the British tiger: it is the fiercest and most destructive beast they have; making dreadful havoc among their poultry, lambs, and kids. It inhabits the most mountainous and woody parts of those islands, living mostly in trees, and feeding only by night. It multiplies as fast as the common cats; and often the females of the latter will quit their domestic mates, and return home pregnant by the former."

The varieties of this animal, in a domestic state, are very numerous: it is either entirely black; black and white; black, fulvous, and white (called the tortoise-shell or Spanish cat); white without any variegation; fulvous and white; dun-colour or tawny, either plain or with deeper stripes; tabby, or of a similar colour to the wild cat, but with much bolder or more vivid variegations; slate-coloured or blue grey (called the Chartreux cat); slate-coloured with very long fur, especially on the neck and tail (the Persian cat); white with hair of a similar length (called the Angora cat); or, lastly, with penciled or tufted ears, like a lynx, which sometimes, though rarely, takes place. Of all the above varieties, the Persian and the Angora are the most remarkable: the latter variety has one eye blue, the other yellow; a particularity which takes place in some specimens of the common white cat. It is also observable, that the white variety of the cat is sometimes perfectly deaf.

The cat, when well educated, possesses qualities which will entitle her to the regard and protection of mankind; and if she does not exhibit the vivid and animated attachment of the dog, she is still of an affectionate and gentle disposition, and grateful to her benefactors.

A singular instance of attachment in the cat is recorded in Mr. Pennant's Account of London. Henry Wriothsly, earl of Southampton, the friend and companion of the earl of Essex in his fatal insurrection, having been confined some time in the Tower, was surprised by a visit from his favourite cat, which, says tradition, reached its master by descending the chimney of his apartment.

No animal, whose habits and manners we have the opportunity of accurately observing, exhibits a greater degree of maternal tenderness than the cat. The extreme assiduity with which she attends her young, and the fondness which she shows for them, afford the most pleasing entertainment to a philosophic observer. She even possesses a propensity to nurse with tenderness the young of a different individual; and it is a general observation, that a domestic cat will commonly suckle and nurse any young kitten that is newly introduced to her.

Nothing can be more beautiful than the experiment of setting a young cat, for the first time, before a looking-glass. The animal appears surprised and pleased with the resemblance, and makes several attempts at touching its new acquaintance; and at length, finding its efforts fruitless, it looks behind the glass, and appears highly surprised at the absence of the figure: it again views itself, tries to touch with its foot, suddenly looking at intervals behind the glass. It then becomes more accurate in its observations, and begins, as it were, to make experiments, by stretching out its hand in different directions; and when it finds that these motions are answered in every respect by the figure in the glass, it seems at length to be convinced of the real nature of the image. The same is the case with the dog at an early age.

The cat generally lives in habits of friendship with the other domestic animals; the contrary instances arising entirely from neglect of early education.

The fur of the cat, being generally clean and dry, readily yields electric sparks when rubbed; and if a clean and perfectly dry domestic cat is placed, in frosty

weather, on a stool with glass feet, or insulated by any other means, and rubbed for a certain space in contact with the wire of a coated vial, it will be effectually charged by this method. See Plate LVII. Nat. Hist. fig. 202.

15. Felis serval. The serval is a native of India and Tibet, and is an extremely fierce and rapacious animal. It resides principally among trees, leaping with great agility from one tree to another, and pursuing birds, &c. This species appears to have been first described by the French academicians in their work entitled Memoires pour servir a l'Histoire des Animaux. The specimen there described measured two feet and a half from the nose to the tail, which was eight inches long. Its shape was thick and strong; its general colour was fox-red or ferruginous, with the throat, abdomen, and insides of the legs, yellow-white; it was spotted almost all over with black, the spots being of a long form on the back, and round on the sides, belly, and legs, where they were proportionally smaller and more numerous. The specimen described and figured in the count de Buffon's Natural History differed only in a very few particulars, so slight as to leave no doubt of the identity of the species. It was excessively fierce and untamable. There is also an American serval, which differs chiefly from the above in being mild and gentle.

16. Felis chaus, is an inhabitant of the woody and marshy tracts that border on the western side of the Caspian Sea, and in the Persian provinces of Ghilan and Masenderan, and is frequent about the mouth of the Kur, the ancient Cyrus. In manners, voice, and food, it agrees with the wild cat. Its general length is about two feet six inches from the nose to the tail; but it has been known to measure three feet: the tail reaches only to the flexure of the legs. The colour of this species is a dusky yellowish-brown; the breast and belly much brighter or more inclining to orange-colour; the tail is tipped with black, and has three obscure black bars at some distance from the tip; and on the inside of the legs, near the bend of the knee, are two dusky bars; the ears are tufted with black hairs.

17. Felis rufa, bay lynx. This species is about twice the size of a large cat, and is a native of North America. Its colour is a bright bay, obscurely marked with small dusky spots; the upper and under lip, throat, and whole under sides of the body and limbs, are white. From beneath each eye three curved blackish stripes pass down the cheeks; the upper part of the inside of the fore legs is marked by two black bars; the upper part of the tail is marked with four or five dusky bars, and that next the tip is black, the ears are sharp-pointed, and tufted with long black hairs. This animal was first described by Guldenstedt. The hair is shorter and smoother than that of the common lynx.

18. Felis caracal. The caracal or Persian lynx is a native both of Asia and Africa; and it is said that in some parts of Persia, it is tamed and made use of in the chace. It is an animal of great strength and fierceness. Dr. Charleton mentions one which killed a hound and tore it in pieces in an instant, notwithstanding the vigorous defence made by the dog. It is used not only in the chace of the smaller quadrupeds, but of the larger kinds of birds, such as herons, cranes, pelicans, &c. which it is said to surprise with great address. When it has seized its prey it lies motionless for some time upon it, holding it in its mouth. The caracal is about the size of a fox, but of a much stronger make; its colour is a pale reddish-brown, whitish beneath; the head is small, the face longish, the ears sharp and slender, of a blackish colour, and terminated by a tuft or pencil of long black hairs.

19. Felis lynx, the common lynx, with some slight varieties as to size and colour, appears to be found in all the colder regions of Europe, Asia, and America, residing in thick woods, and preying on hares, deer, birds, and almost every kind of animal inhabitant. The general size of the lynx is that of a middling dog: the measure given by Mr. Pennant of the skin of a Russian lynx is four feet six inches from head to tail, the tail measuring six inches. But the generality of lynxes seem to be somewhat smaller than this. In colour the lynx varies, but is generally of a pale-grey, with a very slight reddish tinge; the back and whole upper parts are obscurely spotted with small dusky or blackish marks. The throat, breast, and belly, are white; the tail white, with a black tip; the ears tipped with pencils of long black hair. The lynx is said to howl almost in the manner of a wolf. In a state of captivity it seems extremely ferocious, and is not to be tamed. See Plate LVII. Nat. Hist. fig. 199

Felis volans, the flying-cat, an animal supposed to be the same with the flying squirrel.

FELLOES, in fortification, are six pieces of wood, each whereof form a piece of an arch of sixty degrees, and joined altogether by dulleges, make an entire circle; which, with the addition of a nave and twelve spokes, make the wheel of a gun carriage. Their thickness usually is the diameter of the ball of the gun they serve for, and their breadth something more.

FELLOWSHIP, or Company, in arithmetic, is when two or more join their stocks, and trade together, dividing their gain or loss proportionably.

Fellowship is either with or without time. Questions without time, or in the single rule of fellowship, as it is frequently called, are wrought by the following proportion:

As the whole stock, to the whole gain or loss, so is each man's particular stock, to his particular gain or loss.

Example I. A, B, and C, make a joint stock: A puts in 460*l.*, B 510*l.*, and C 480*l.*; they gain 340*l.*; what part of it belongs to each?

In order to the solution of this question, find the total of their joint stock, viz.

A's stock 460*l.* + B's stock 510*l.* + C's stock 480*l.* = 1450*l.* the total stock.

Then 1. To find A's share of the gain, state as follows: If 1450*l.* : 340*l.* :: 460*l.*, which being worked by the rule of three, the answer will be 107*l.* 17*s.* $2\frac{3}{4}$*d.* for A's share of the profit.

2. B's share of the gain, by stating thus: if 1450*l.* : 340*l.* :: 510*l.* and working by the rule of three, will be found to be 119*l.* 11*s.* $8\frac{1}{2}$*d.*

3. C's share will appear 112*l.* 11*s.* $6\frac{1}{4}$*d.* when worked as before, after having stated thus: If 1450*l.* : 340*l.* :: 480*l.*

Example II. Suppose three partners, A, B, and C,

make a joint stock in this manner: A puts in 24*l.*, B 32*l.*, and C 40*l.*, in all 96*l.*, with which they trade, and gain 12*l.*; required each man's true share of that gain? The first operation for A's part of the gain will stand thus:

96*l.* : 12*l.* :: 24*l.* : 3*l.* = A's gain.
96*l.* : 12*l.* :: 32*l.* : 4*l.* = B's gain.
96*l.* : 12*l.* :: 40*l.* : 5*l.* = C's gain.

Proof 3*l.* + 4*l.* + 5*l.* = 12*l.* the whole gain.

That is, if the total of all their particular gains amounts to the whole gain, the work is true; if not, some mistake has been committed.

Fellowship *with time*, usually called the *double rule of fellowship*, because every man's money is to be considered with relation to the time of its continuance in the joint stock. It is worked thus: multiply each man's stock by the respective time he puts it in for, and add all the products; the total of which must be your first number through all the statings; the gain or loss the second, as before; and each man's particular stock, multiplied by its time, the third.

Example I. A put into company 560*l.* for eight months, B 279*l.* for ten months, and C 735*l.* for six months; they gained 1000*l.* What share of it must each have?

For the solution of this question, proceed as follows: A's stock 560*l.* × 8 its time = 4480; B's stock 279*l.* × 10 its time = 2790; C's stock 735*l.* × 6 its time = 4410. Then 4480 + 2790 + 4410 = 11680.

Now, 1. To find A's share of the profit, state thus: If 11680*l.* : 1000*l.* :: 4480*l.* which being worked by the rule of three, the answer will be 383*l.* 11*s.* $2\frac{1}{4}$*d.* for A's share of the gain.

2. For finding B's share state thus: If 11680*l.* : 1000*l.* : : 2790*l.* and working as before directed, the answer will be 238*l.* 17*s.* $3\frac{3}{4}$*d.*

3. To find C's proportion of the gain, say, if 11680*l.* : 1000*l.* : : 4410*l.* then working it by the rule of three, the true amount of his share will appear to be 377*l.* 11*s.* $4\frac{1}{4}$*d.*

FELO DE SE, a felon of himself, is a person who, being of sound mind, and of the age of discretion, voluntarily kills himself: for if a person is insane at the time, it is no crime. But this ought not to be extended so far as the coroner's juries sometimes carry it, who suppose that the very act of self-murder is an evidence of insanity; as if every man who acts contrary to reason had no reason at all; for the same argument would prove every other criminal non compos, as well as the self-murderer. 3 Inst. 54.

All inquisitions of the offence, being in the nature of indictments, ought particularly and certainly to set forth the circumstances of the fact; as the particular manner of the wound, and that it was mortal, &c. and in conclusion add, that the party in such manner murdered himself. 1 Salk. 377.

A felo de se forfeits all chattels real and personal, which he has in his own right; and also all such chattels real whereof he is possessed, either jointly with his wife, or in her right; and also all bonds and other personal things in action, belonging solely to himself; and also all personal things in action and intire chattels in possession, to which he was entitled jointly with another, on any account, except that of merchandize; but it is said that he shall forfeit a moiety only of such joint chattels as may be severed, and nothing at all of what he was possessed of as executor or administrator. Standf. P. C. 188, 189. Plow. 243, 262. 3 Inst. 55.

FELONY, in the general acceptation of law, comprises every species of crime which occasioned at common law the forfeiture of lands or goods. This most frequently happens in those for which a capital punishment either was or is liable to be inflicted; for those felonies which are called clergyble, or to which the benefit of clergy extends, were anciently punished with death in lay or unlearned offenders; though now, by the statute law, that punishment is for the first offence universally remitted.

Felony is always accompanied with an evil intention, and therefore shall not be imputed to a mere mistake or misanimadversion; as where persons break open a door to execute a warrant, which will not justify such a proceeding. But the bare intention to commit a felony is so very criminal, that at the common law it was punishable as felony, where it missed its effect through some accident, which no way lessened the guilt of the offenders; but it seems agreed at this day, that felony shall not be imputed to a bare intention to commit it, yet it is certain that the party may be very severely fined for such an intention. 1 Haw. 65.

The punishment of a person for felony, by our ancient books, is, 1st, to lose his life; 2dly, to lose his blood, as to his ancestry, and so to have neither heir nor posterity; 3dly, to lose his goods; 4thly, to lose his lands, and the king shall have year, day, and waste, to the intent that his wife and children be cast out of the house, his house pulled down, and all that he had for his comfort and delight destroyed. 4 Rep. 124. A felony by statute incidentally implies, that the offender shall be subject to the like attainder and forfeiture, &c. as is incident to a felon at common law. 3 Inst. 47. See Burglary, Forgery, Homicide, Petit Treason, Rape, Robbery, &c.

Felon's goods are not forfeited till it is found by indictment that he fled for the felony, and therefore they cannot be claimed by prescription. See Estrays, and Waifs.

Felony *under colour of law:* such is coming into a house by colour of writ of execution, and carrying away the goods. A special trust prevents the felony, until such special trust is determined. 8 Mod. 76.

FELT, in commerce, a sort of stuff, deriving all its consistence merely from being fulled or wrought with lees and size, without either spinning or weaving. Felt is made either of wool alone, or of wool and hair.

FELSPAR. See Lepidolite.

FELUCCA, in sea affairs, a little vessel with six oars, frequent in the Mediterranean, which has this peculiarity, that its helm may be applied either in the head or stern as occasion requires.

FEME covert, a married woman, so called from being under the cover, protection, and influence of her husband. See Husband and Wife.

Feme sole, a single or unmarried woman. A feme sole is liable to perform parish offices, the act only requiring the person to be a substantial householder, without reference to sex.

Feme sole trader, a married woman, who, by the custom of London, trades on her own account, independant of her husband. See Bankruptcy.

FEMININE, or Fœminine, in grammar, one of the genders of nouns.

FEMUR, *os femoris*, the thigh-bone. See Anatomy.

FEN, a place overflowed with water, or abounding with bogs. See Draining.

Fens are either made up of a congeries of bogs, or consist of a multitude of pools or lakes with dry spots of land intermixed, like so many little islands.

Several statutes have been made for the draining of fens, chiefly in Kent, Cambridgeshire, Bedfordshire, Lincolnshire; by 11 Geo. II. commissioners shall be appointed for the effectually draining and preserving of the fens in the isle of Ely, who are authorised to make drains, dams, and proper works thereon; and they may charge the landholders therein with a yearly acre-tax, and in default of payment sell the defaulters' lands.

FENCE, in country affairs, a hedge, wall, ditch, bank, or other inclosure, made around gardens, woods, cornfields, &c. See Husbandry.

Where a hedge and ditch join together, in whose ground or side the ditch is, to the owner of that land belongs the keeping of the same hedge or fence, and the ditch belonging to it on the other side, in repair and scoured. P. Off. 188.

An action on the case or trespass lies for not repairing fences, whereby cattle come into the ground of another, and so damage it. Also it is presentable in the court baron. 1 Salk. 335.

Fence month, a month wherein it is unlawful to hunt in the forest, because the female deer fawn in that time: it being always, according to the charter of the forest, 15 days before, and ending 15 days after Midsummer.

FENCING, the art of making a dexterous use of the sword, as well for attacking an enemy, as for defending one's self.

FEND, in the sea language, imports the same as defend: thus, fending the boat is saving it from being dashed to pieces against the rock, shore, and ship's side. And hence,

FENDERS are pieces of old hawsers, cable-ropes, or billets of wood, hung over the ship's sides, to keep other ships from rubbing against and injuring her.

FENDUE *en pal*, in heraldry, a cross cloven down in pale, that is, from top to bottom, and the two parts set at some distance from each other.

FENESTRA, in anatomy, a term applied to two openings or foramina within the ear, distinguished by the names of the oval and the round fenestra. The fenestra ovalis leads to the vestibule, on which stands the stapes. The fenestra rotunda leads to the cochlea, and is closed by a membrane.

FENNEL. See Anethum.

FENS. Any person convicted of maliciously cutting or destroying any bank, mill, engine, floodgate, or sluice for draining fens, shall be guilty of felony, without benefit of clergy. 27 Geo. II. c. 19.

FEODEL system, the constitution of fiefs or euds. It is about twelve centuries ago since this systen was so universally received in Europe, that sir Henry Spelman calls it the law of nations in our western world. Hence it deserves our attention in a particular manner; a knowledge of the different feuds being indispensably resquisite for a proper understanding either of the civil government of our country, or the laws by which its landed property is regulated.

The military policy of the Celtic or northern nations, known by the names of Goths, Vandals, Franks, Huns, and Lombards, furnished the original constitution or system of feuds. These people pouring out in vast multitudes from the officina gentium or store-house of nations, overran all the European nations on the decline of the Roman empire. They brought the feudal system along with them from the countries out of which they emigrated; and supposing it to be the most proper method of securing their new conquests, they introduced it into their more southerly colonies.

According to this system, the victorious general allotted considerable tracts of land to his principal officers; while they, in like manner, divided their possessions among the inferior officers, and even those common soldiers who were thought to be the most deserving. Allotments of this kind were named feoda, fiefs, fees, or feuds, form a combination of words, in the language of these barbarians, signifying a reward or stipend bestowed on certain conditions. The condition upon which these rewards were given was, that the possessors should faithfully serve the person from whom they were received, both at home and abroad, in a military capacity. To this they engaged themselves by a juramentum fidelitatis, or oath of fealty; in the event of a breach of which, either by not performing the service agreed upon, by deserting their lord in time of battle, &c. the lands were to return to their original possessor.

Thus the possessors of feodal allotments became interested in the defence of them; and not only the receivers, but those who gave them, were equally and mutually bound to defend their possessions, none of them being able to pretend any right but that of conquest. For this purpose, government and subordination were absolutely necessary; it being impossible to conduct any system of defence where every thing was tumultuous and irregular. Every person, therefore, who was a feudatory, *i. e.* who had received lands, was bound to do every thing in his power to defend the lord of his fee; while, on the other hand, the latter was no less subordinate to his immediate superior; and so in succession to the prince himself. In like manner a reciprocal bond of defence existed down from the prince to the lowest feodists.

Such were the foundations on which the feodal system was properly established; and the natural consequence was, a military subjection throughout the whole community. The prince could always collect an army of feudatories ready to defend not only the kingdom in general, but the particular possessions of each person; and the propriety of this constitution was soon apparent in the strength which these newly-erected kingdoms acquired, and the valour with which their conquests were defended.

Besides these feodal grants, however, which were held only on the terms of military service, there were others called allodial, which were given upon more enlarged

principles. To these every free man had a title, and could not only claim his territory as well as the rest, but dispose of it at his pleasure; and this freedom was denominated allodiality. These allodials, however, were not exempted from military service. A part of their freedom consisted in liberty to go to the wars; for this, in the barbarous times we speak of, was the only way to acquire any degree of renown. Only the slaves were destined to follow the arts of peace; while every free person was not only at liberty to defend his country, but under an obligation to do it in case of any urgent necessity.

Thus there was a feodal and a national militia. The free people only were allowed to possess property; the feudal vassals constituted the army, properly so called; while the national militia was composed of the allodial proprietors. This allodiality, however, was not confined to landed property, but included likewise moveable estates or money; so that proprietors of the latter kind were obliged also in times of danger to bear arms and appear in the field. Between the feodal and allodial proprietors, however, there was this farther difference, that the latter had no concern with any private quarrels which might take place among the lords themselves; so that they were never obliged to appear in the field unless when called forth by the sovereign against the enemies of the nation at large. This circumstance we might suppose to be an advantage, but it ultimately operated otherwise; becoming the means of changing the allodial right into a feodal tenure. For some time the holders of fiefs had an eminent advantage over the allodial proprietors. This was owing to the imperfection of government in those days; so that the nobles had it in their power to revenge their own quarrels, while the weak were equally exposed to the insults of both parties. The lord and his vassals, therefore, were always formidable; but the allodial proprietors had scarcely any means of defending themselves. The reason of this was, in the first place, that the law did not allow them to commit any hostilities; and in the next, they were too distant and unconnected to form any proper league for mutual defence; and hence proceeded the necessity already hinted at, of converting allodial property into feudal tenure. This was indeed owing in a great measure to the absurdity and violence of the times, by which gifts of property, burthened with service, and which might return to the person who granted them, were rendered superior in value to the absolute and unconditional possession of a subject. Other considerations, however, contributed to produce the same effect. As in those dark ages no right existed but what had its origin in conquest, it thence followed that the greatest conqueror or warrior was the most honourable person. The king, in whom the whole exploits of the community centred, as being their head, was the most honourable person; and all others derived from him that portion of honour which they enjoyed, and which was most nicely adjusted in proportion as they approached him. Allodial proprietors, therefore, having no pretensions of this kind, were treated with contempt. From this disagreeable situation they wished to free themselves, by converting their allodial property into feudal tenures; while the princes, supposing it their interest to extend those tenures as much as possible, discouraged the allodial possessions. As the feodists supported the importance of the nation and dignity of the monarch, it was not thought proper to allow the allodial proprietors any greater compensations than what were given to vassals in similar cases. Thus they were exposed to continual mortifications in the courts of justice; they were neglected by the king; denied sufficient protection from the laws; exposed not only to continual insults, but to have their property on all occasions destroyed by the great; so that they were without resource except from the feodal tenures, and were obliged even to solicit the privileges which were bestowed in other cases on vassals. In these unhappy circumstances, they were glad to yield up their lands to any superior whom they thought most agreeable, and to receive them back from him as a feudal gift. Thus the landed property was every where changed into feudal tenures, and fiefs became universal.

For some time the feodal system was not only useful in itself, but honourable in its principles; but this continued no longer than while the importers of it into Europe adhered to their original simple and noble maxims. During that period, the lord exercised his bounty to the vassal, which the latter repaid by acts of gratitude; so that the intercourse betwixt them was of the most tender and affectionate kind; and this gave rise to what are called the feodal incidents.

The expectants of fiefs were educated in the hall of the superior, while the tenures were precarious or only for life: and even when they became hereditary, the lord took care of the son and estate of his deceased vassal, not only protecting his person, but taking charge of his education, and directing the management of his affairs. He took pleasure in observing his approach to maturity; and when he came of age, never failed to deliver to him the lands, with the care of which he had been entrusted, and which he had been careful to improve. This was called the incident of wardship.

The incident of relief was founded upon the gratitude of the vassal, who, upon entering on his fief, brought a present to his lord, as an acknowledgment of his care of him during the early part of his life, and in order to conciliate his future regard.

The incident of marriage proceeded also upon the principal of gratitude on the part of the vassal. The latter, conscious of the favours he had received, did not choose to ally himself with a family inimical to his chief; while the superior himself, ambitious to aggrandise and augment the importance of his family, sought how to find the most advantageous match for his vassal.

Sometimes the superior himself was reduced in his circumstances by war or other accidents; but from whatever cause his distress proceeded, even though it had arisen from his own extravagance or prodigality, or when only destitute of means to support his ambition or grandeur, his vassals were bound to support and relieve him according to their circumstances; and this was called the incident of aid.

The incident of escheat took place on the part of the vassal, when, through cowardice, treachery, or any remarkable misbehaviour, he rendered himself unworthy of his fief. In that case, the taking it from him, and giving it to one more worthy, was called an escheat.

While the lords and vassals thus vied with one another in mutual acts of friendship and benevolence, happiness, liberty, and activity, were diffused through the society. The vassals behaved courteously towards the retainers, who were immediately below them; while they again were courted by the lords, as constituting their importance and strength: the lords, lastly, giving a like importance and dignity to the sovereign himself. Thus a regular, powerful, and compact system of government took place, an unanimity and attention pervaded the various departments of state; so that while the subjects were free, the nation at large was formidable.

During this state of affairs, the members of the national assembly in every country of Europe appeared there in arms, whether they came personally or by their representatives. Such particularly was the case under the Anglo-Saxon government; and the happiness they at that time enjoyed made the oppression and tyranny of the Normans appear the more intolerable. In process of time, however, the state of society began to suffer a remarkable alteration. The high and disinterested notions from which the happiness above-mentioned took its origin, declined; the romantic ideas of chivalry ceased; and much more interested notions of property came in their stead. The separation of the interests of the lords from their vassals was the first step towards the destruction of the feodal system. Thus the incidents, which, as has just now been mentioned, promoted their happiness, did the very reverse. Property, being now looked upon as a distinction superior to personal merit, naturally introduced the most mercenary views. In consequence of these, the infant ward, the care of whom was wont to be considered as a sacred and honorary trust, was now only looked upon as a means of procuring emolument to the superior. The latter now regarded the profits of his vassals as so many diminutions of his own wealth. Instead of taking care to improve the estate of his ward as formerly, he impoverished it; not only neglecting the education of the heir, but offering insults to himself; insomuch that the relations of the unfortunate vassal were frequently obliged to ransom from the avaricious superior both his person and effects. By merchandise of this kind the coffers of princes were filled, and wardships let out to strangers, who might exercise their rapacity with greater freedom. When the vassal at last attained the years of maturity, he came to the possession of his lands without any of that joy and festivity which usually took place on the occasion. He received an inheritance wasted and destroyed, while new grievances daily presented themselves to augment the horrors of his situation. All the incidents, which in former times were so many expressions of gratitude on the part of the vassal, were now changed into taxes which might be exacted at the pleasure of the lord. Before the vassal was invested in his land, the superior exacted from him a certain sum or other gift, to be measured only by his own rapacity; and in case of delay or inability to pay this demand, the superior continued in possession of the estate. Such scandalous oppression could not but produce the greatest discontent and clamour. Applications were made to the law without success; nor were even the laws regarded which were fabricated on purpose for their relief. The incident of marriage now proved a source of the most dreadful oppression. The lord assumed a right of marrying his vassal to whom he pleased; and he not only exerted this right himself, but would sell it to a stranger, or allow the vassal to buy it himself; while the penalty annexed to a marriage without the consent of the superior involved no less punishment than the loss of the estate itself, or some grievous infliction as for a crime of the first magnitude. The case was still worse with a female ward, whose beauty and accomplishments became a source of gain to the superior, or were sacrificed to please his whim or caprice; so that her relations were frequently obliged to buy from him the privilege of marrying her to the person she or they thought most proper. In like manner the aid, which was formerly a voluntary gift from the vassal in cases of distress happening to his lord, now became an unavoidable tax. An aid formerly was demanded, when the eldest daughter of the superior was married, when his eldest son was knighted, or when the superior himself was taken prisoner in battle. These were the only legal causes of making a demand of this kind; but, in the subsequent times of degeneracy, the most frivolous pretences were every day made use of by the prince to oppress the lords, and by the lords to oppress their vassals; demanding subsidies at pleasure, which their inferiors were always obliged to comply with. Lastly, the escheat, which in former times took place only in cases of cowardice, treachery, or some other heinous crime, was now inflicted on the most trifling occasions. If the vassal happened to be too long in attending the court of his superior to take the oath of fealty; if he committed any action which could in the least be construed an infringement of the oath; if he neglected to give his lord warning of any misfortune which he might suppose was about to befal him; revealed any thing concerning him; made love to his sister or daughter, &c.; or even if he should grant a tenure of land to another person in form different from that in which he held his own; all these, nay others still more ridiculous, were judged sufficient reasons for the superior to seize on the estate of the vassal, and involve him and his family in ruin.

Notwithstanding these oppressions, however, the vassal was still obliged to submit to his lord, to own him as his superior, and even in appearance to pay him the same respect as formerly, when the greatest unanimity and cordial affection subsisted between them. Still he was obliged to perform the same military service; because a failure in that respect would have subjected him to a forfeiture of lands according to the original agreement. A vast difference, however, now took place in the valour and activity which inspired the army. The vassals, forced into the field with desponding hearts, were indifferent as to the success of the cause in which they were engaged, and frequently obstructed instead of forwarding the operations of the field. Hence the sovereign found himself embarrassed; and, though nominally at the head of a martial and powerful people, was frequently unable to effect any thing on account of the mutual hatred and dissension which every where prevailed.

Thus the feodal states of Europe became unnaturally weak; a remedy was necessary; and it is remarkable, that the same remedy was applied all over the continent. This was, in short, the making fiefs hereditary, which

till now had only been granted for a long term of years; and, in return, burdening the lands with a certain number of soldiers, which were not to be refused on any pretence whatever. Hence was derived the tenure of knight-service. A certain portion of land, burdened with the service of one horse-soldier or knight, was called a knight's fee; and thus an estate, furnishing any number of soldiers, was said to contain as many knight's fees; so that now the manors, baronies, &c. become powerful according to the number of soldiers they were bound to furnish. In the grants from the crown, the nobility were obliged to furnish a certain number of soldiers for the service of the sovereign; and in those from the nobility to their vassals the like service was required. Even the commons who had grants from the crown furnished a certain proportion of knights or cavalry. The force of the nation was called into action by grants in capite, or from the sovereign and nobility. A numerous and powerful army was instantly assembled, and at once ready for action. Of this army the king was the general, the nobility were the officers, and the vassals soldiers, the whole being exactly arranged, and capable of entering upon any expedition without the least delay.

Thus a remedy was found in some measure for the weakness of the feodal sovereigns; but, though the knight's-tenure could accomplish this, it could not bring back the former affection and cordiality which subsisted between the various ranks of people. On the contrary, by uniting them more firmly to one another by legal ties, it rendered matters rather worse. The oppression originating from the operation of the feodal incidents still continued with unremitting violence. The grants of knight's-tenure were attended with the same oaths of homage and fealty; the same incidents of relief, wardship, marriage, aid, and escheat; with the feodal tenures. The princes promised to abate somewhat of their rigour in demanding the feodal perquisites, but did not keep their word. Laws were occasionally promulgated, and for some time had an effect; but palliatives soon became ineffectual, and a new state of weakness commenced.

The two remarkable eras in the feodal history are, the time before the invention of knight's-service, and that during which it continued. Fiefs were in a state of fluctuation from the destruction of the Roman empire till the ninth century; but they were rendered perpetual in France about the year 877, and were generally become so in every country in Europe about the beginning of the tenth. Du Cange, *voce Militia*, gives us an example of a knight's fee in the year 880. By the year 987, when Hugh Capet was raised to the throne of France, knight-service was become general all over Europe, and was introduced into England, after having made its appearance in other countries. In England, however, there have been several doubts and difficulties among the learned concerning the introduction of the feodal laws. Many are of opinion, that they were first introduced by William the Conqueror, and, consequently, that they were entirely unknown to the Anglo-Saxons: but others think that they existed among the latter in the same form under which they were continued by the Normans. Dr. Stuart is of opinion, that the Saxons who settled in England could not be strangers to fiefs. He supposes the conformity of manners, which undoubtedly prevailed between the Saxons and other barbarians, a sufficient proof that the hereditary grant of land, as well as the fluctuating state of feodal tenures which preceded it were known to the former. Collateral proofs are derived from the spirit and tenure of the Anglo-Saxon laws, but especially from the grants of hereditary estates on condition of military service. The condition of fiefs, however, under the Anglo-Saxons, was very different from what it was afterwards. In their times, we find no mention made of those oppressions of which so much notice has already been taken; and this may easily be accounted for from the alteration of the feodal spirit in different ages. During the time that a warm and generous affection subsisted between the feodal superiors and vassals, the incidents were marks of generosity on the one part and gratitude on the other; but as soon as a variance had taken place, from the interested disposition which the introduction of luxury produced, the same incidents became sources of the most flagrant oppression. This was remarkably the case in the time of William the Conqueror; and during the reign of king John matters were come to such a crisis, that the people every where complained loudly, and demanded the restoration of the laws of Edward the Confessor. "What these laws of Edward the Confessor were (says Mr. Hume) which the English, every reign during a century and a half, desired so passionately to have restored, is much disputed by antiquarians; and our ignorance of them seems one of the greatest defects of the ancient English history." Dr. Stuart has offered an explanation; but this is in fact no more than a conjecture, that "by the laws or customs of the Confessor, that condition of felicity was expressed which had been enjoyed during the fortunate state of the feodal association. The cordiality, equality, and independance, which then prevailed among all ranks in society, continued to be remembered in less prosperous times, and occasioned an ardent desire for the revival of those laws and usages which were the sources of so much happiness."

Besides the great distinction (of which an account has already been given) between the state of fiefs under the Anglo-Saxons and under the Normans, they were no less istinguished by the introduction of knight's-service. Hitherto the refinement of the English had been obstructed by the invasion of the Danes, and the insular situation of the kingdom; but after the Norman conquest the fiefs were made perpetual. Still, however, the knight's-fee and knight's-service were altogether unknown. William, the sixth prince who enjoyed the duchy of Normandy, was well acquainted with every thing relating to fiefs; for that dutchy had experienced all the variety incidental to them, from the time of its being granted to Rollo by Charles the Simple, in the year 912, to the year 1066, when William was put in possession of England by the battle of Hastings.

On his accession to the throne, a number of forfeitures took place among those who had followed the fortunes of Harold. Their estates were to be disposed of at the pleasure of the conqueror; and it was natural to suppose that he would follow the method practised in his own country. Hence the origin of knight's-service in England. A grant of land to any person whatever, was estimated at a certain number of knight's-fees; and each of these required the service of the knight. The grants of

lands were even renewed to the old tenants under this tenure; so that by degrees the whole military people in the kingdom acquiesced in it. To accomplish this, Domesday-book is supposed to have been compiled, which contained an exact account of all the landed property in the kingdom. Hence it is to be concluded, not that William introduced fiefs into England, as some have imagined, but that he brought them to their ultimate state of perfection by the introduction of knight's-service. This is evident from the laws enacted during his reign. In these it is not only mentioned that knight's-service was enacted, but that it was done expressly with the consent of the common council of the nation; which at that time was equivalent to an act of parliament.

The invention of knight's-service proved generally agreeable: for, as few of the Anglo-Saxon fiefs were hereditary, the advancement of the rest to perpetuity, under the tenure of knight's-service, must have been accounted an acquisition of some importance, as not only augmenting the grandeur and dignity of the sovereign, but securing the independence of the subject, and improving his property. In the happy state of the feodal association, there was indeed no necessity for the knight's-fee; but when the discordance and oppression so often mentioned began to take place, it became then necessary to point out particularly every duty of the vassal as well as of the lord; and this was fully done by the invention of knight's-service. The nobles possessed duchies, baronies, and earldoms, which extensive possessions were divided into as many fees, each of them to furnish a knight for the service of the king or of the superior; so that every feodal state could command a numerous army and militia, to support and defend it in case of any emergency. The knights were also bound to assemble in complete armour whenever the superior thought proper to call, and to hold themselves in readiness for action whenever the king or superior found it convenient to take the field; so that thus the militia might be marched at the shortest notice to defend or support the honour of the nation.

The knights were usually armed with an helmet, sword, lance, and shield; and each was besides obliged to keep a horse. This last requisite was owing to the contempt into which the infantry had fallen, through the prevalence of tournaments and luxuries of various kinds, though it was by means of the infantry that the barbarians had originally distinguished themselves in their wars with the Romans, and become able to cope with those celebrated warriors. All proprietors of fees or tenants by knight's-service fought on horseback; the cavalry were distinguished by the name of battle, and the success of every encounter was supposed to depend on them alone. They only were completely armed; the infantry, being furnished by the villages under the jurisdiction of the barons, had at first only bows and slings, though afterwards they were found worthy of much greater attention.

While the feodal association remained in perfection, the superior could at any time command the military service of his vassals; but, in the subsequent degeneracy, this service could neither be depended upon when wanted, nor was it of the same advantage when obtained as formerly. The invention of knight's-service tended in a great degree to remedy this inconvenience. Those who were possessed of knight's-fees were now obliged to remain forty days in the field at their own expense; and this without exception, from the great crown vassals to the smallest feudatories: but if longer service was required, the prince was obliged to pay his troops. In those times, however, when the fate of nations was frequently decided by a single battle, a continuance in the field for 40 days was sufficient for ordinary occasions.

Thus matters seemed once more to be restored nearly to their former state. It was now, as much as ever, the interest of the nation to act with unanimity in its defence, not only against foreign enemies, but against the tyranny of the prince over his subjects, or of one part of the subjects over the other. New inconveniences, however, soon began to take place, owing to the gradual improvements in life and the refinement of manners. From the first institution of military service, a fine had been accepted instead of actual appearance in the field. In the times of barbarity, however, when men accounted rapine and bloodshed their only glory, there were but few who made an offer of this compensation; but as wealth and luxury increased, and the manners of people became softer, a general unwillingness of following the army into the field became also prevalent. A new tenure called *escuage*, was therefore introduced, by which the vassal was only obliged to pay his superior a sum of money annually instead of attending him into the field. Hence originated taxes and their misapplication; for as the king was lord paramount of the whole kingdom; it thence happened that the escuage-money collected throughout the nation centred in him. The princes, then, instead of recruiting their armies, filled their coffers with the money, or dissipated it otherwise, hiring mercenaries to defend their territories when threatened with any danger. These being composed of the dregs of the people, and disbanded at the end of every campaign, filled all Europe with a disorderly banditti, who frequently proved very dangerous to society. To avoid such inconveniences, standing armies were introduced, and taxations began to be raised in every European kingdom. New inconveniences arose. The sovereigns in most of these kingdoms, having acquired the right of taxation, as well as the command of the military power, became completely despotic; but in England the sovereign was deprived of this right by Magna Charta, which was extorted from him, as related in English histories; so that, though allowed to command his armies, he could only pay them by the voluntary contributions of the people, or their submitting to such taxations as were virtually imposed by themselves.

The tenure by knight's-service was continued in Great Britain (nominally at least), with all the incidents, homage, fealty, escuage, wardship, marriage, &c. till the time of the civil wars, when it was abolished by the Long Parliament, and the abolition was confirmed by 12 Car. II. c. 24.

FEOFFMENT, may be defined to be the gift of any corporeal hereditament to another. He that so gives or enfeoffs, is called the feoffor, and the person enfeoffed is denominated the feoffee. 2 Black. 20. But by the mere words of the deed, the feoffment is by no means perfected. There remains a very material ceremony to be performed, called livery of seisin, without which the feoffee has but a mere estate at will. Id.

The end and design of this institution was by this sort

of ceremony or solemnity, to give notice of the translation of the feud from one hand to another; because if the possession might be changed by the private agreement of the parties, such secret contract would make it difficult and uncertain to discover in whom the estate was lodged, and consequently the lord would be at a loss of whom to demand his services, and strangers equally perplexed to discover against whom to commence their actions for the prosecution and recovery of their right. To prevent, therefore, this uncertainty, the ceremony of livery and seisin was instituted. 2 Bac. Abr. 482.

Of the several sorts of livery. The livery in deed is the actual tradition of the land, and is made either by the delivery of a branch of a tree or a turf of the land, or some other thing, in the name of all the lands and tenements contained in the deed; and it may be made by words only, without the delivery of any thing; as if the feoffor upon the land, or at the door of the house, says to the feoffee, "I am content that you should enjoy this land according to the deed." This is a good livery to pass the freehold. Co. Lit. 48. *a.*

The livery within view, or the livery in law, is when the feoffor is not actually on the land or in the house, but being in sight of it, says to the feoffee, "I give you yonder house or land; go and enter into the same, and take possession of it accordingly." This livery in law cannot be given or received by an attorney, but only by the parties themselves. Pollex, 47.

But this sort of livery is not perfect to carry the freehold, till an actual entry made by the feoffee, because the possession is not actually delivered to him, but only a licence or power given him by the feoffor to take possession of it; and therefore if either the feoffor or feoffee dies before livery, and entry made by the feoffee, the livery within the view becomes ineffectual and void; for if the feoffor dies before entry, the feoffee cannot afterwards enter, because then the land immediately descends upon his heir, and consequently no person can take possession of his land without an authority delegated from him who is the proprietor; nor can the heir of the feoffee enter, because he is not the person to whom the feoffor intended to convey his land, nor had he an authority from the feoffor to take the possession: besides, if the heir of the feoffee was admitted to take possession after his father's death, he would come in as a purchaser; whereas he was mentioned in the feoffment to take as the representative of his ancestor, which he cannot do, since the estate was never vested in his ancestor. Co. Lit. 48. b.

A feoffment cannot be made of a thing of which livery cannot be given, as of incorporeal inheritances, such as rent, advowson, common. &c. 2 Rol. 1. *l.* 20.; though it be an advowson, &c. in gross. 21 Id.

A man may either give or receive livery in deed, by letter of attorney; for since a contract is no more than the consent of a man's mind to a thing, where that consent or occurrence appears, it would be most unreasonable to oblige each person to be present at the execution of the contract, since it may as well be performed by any other person delegated for that purpose by the parties to the contract. Co. Lit. 52.

There are few or no persons excluded from exercising this power of delivering seisin; for monks, infants, femes covert, persons attainted, outlawed, excommunicated, villains, aliens, &c. may be attorneys; for this being only a naked authority, the execution of it can be attended with no manner of prejudice to the persons under these incapacities or disabilities, or to any other person who by law may claim any interest of such disabled persons after their death. Co. Lit. 52. *a.* See Fine.

FEOFFOR and Feoffee. Feoffor is he who infeoffs or makes a feoffment to another of lands or tenements in fee simple; and feoffee is the person infeoffed, or to whom the feoffment is made. See Feoffment.

FERÆ, in zoology, an order of quadrupeds, the distinguishing characters of which are, that all the animals belonging to it have fore-teeth conic, usually six in each jaw; tusks longer; grinders with conical projections; feet with claws; claws subulate; food, carcases, and preying on other animals. See Natural History, Zoology, &c.

Feræ naturæ. Animals of a wild nature are those in which a man has not an absolute but only a qualified and limited property, which sometimes subsists, and at other times does not subsist. And this qualified property is obtained either by the art and industry of man, or the impotence of the animals themselves, or by special privilege.

A qualified property may subsist in animals *feræ naturæ*, by the art and industry of man, either by his reclaiming and making them tame, or by so confining them that they cannot escape and use their natural liberty; such as deer in a park, hares or conies in an enclosed warren, doves in a dovehouse, pheasants or partridges in a mew, hawks that are fed and commanded by the owner, and fish in a private pond or in trunks. These are no longer the property of a man than while they continue in his keeping or actual possession; but if at any time they regain their natural liberty, his property instantly ceases, unless they have animum revertendi, which is only to be known by their usual custom of returning.

A man may have a qualified property in animals feræ naturæ, by special privilege; that is, he may have the privilege of hunting, taking, and killing them, in exclusion of other persons: under which head may be considered all those animals which come under the denomination of game. Here a man may have a transient property in these animals, so long as they continue within his liberty, and may restrain any strangers from taking them therein, but the instant they depart into another liberty, this qualified property ceases. 2 Black. 391.

Larceny cannot be committed of things feræ naturæ, while at their natural liberty; but if they are made fit for food, and reduced to tameness, and known by the taker to be so, it may be larceny to take them. 1 Haw. 94. See Game.

FEE de fourchette, in heraldry, a cross having at each end a forked iron, like that formerly used by soldiers to rest their musquets on. It differs from the cross fourché, the ends of which turn forked, whereas this has that sort of fork fixed upon the square end.

FERENTARII, in Roman antiquity, were auxiliary troops, lightly armed; their weapons being a sword, bow, arrows, and a sling.

FERIÆ, in Roman antiquity, holidays, or days upon which they abstained from work.

The Romans had two kinds of feriæ: 1. The public, common to all the people in general. 2. The private, which were only kept by some private families.

The public feriæ were fourfold: 1. Stativæ friæ, holidays which always fell out upon the same day of the month, and were marked in the calendar: of these the chief were the agonalia, carmentalia, and lupercalia. 2. Conceptivæ feriæ, holidays appointed every year upon certain or uncertain days by the magistrates or the pontiff: such were the Latinæ, paganalia, compitalia, &c. 3. Imperativæ feriæ, holidays commanded or appointed by the authority of the consuls or prætors: of this kind we may reckon the lectisternium. 4. Nundinæ, the days for fairs. The private feriæ were either confined to private families or particular persons, as birth-days; and those expiations upon the tenth day after a person died in a house, called feriæ denicales. From this term our word fair seems to be derived.

FERIA, in the Romish breviary, is applied to the several days of the week: thus Monday is the feria secunda, Tuesday the feria tertia, though these days are not working days, but holidays. The occasion of this was, that the first Christians used to keep the Easter-week holy, calling Sunday the prima feria, &c. whence the term feria was given to the days of every week. But besides these, they have extraordinary feriæ, viz. the last three days of passion-week, the two days following Easter-day, and the second feriæ of rogation.

FERMENTATION. During the spontaneous decomposition which vegetable substance undergo, it is obvious that the simple substances of which they are composed must unite together in a different manner from that in which they were formerly united, and form a new set of compounds which did not formerly exist. The specific gravity of these new compounds is almost always less than that of the old body. Some of them usually fly off in the state of gas or vapour. Hence the odour that vegetable bodies emit during the whole time that they are running through the series of their charges. When the odour is very offensive or noxious, the spontaneous decomposition is called putrefaction; but when the odour is not offensive, or when any of the new compounds formed is applied to useful purposes, the spontaneous decomposition is called fermentation. The term is supposed by some to have originated from the intestine motion which is always perceptible while vegetable substances are fermenting; while by others it is derived from the heat which in these cases is always generated. It is now very often applied to all the spontaneous changes which vegetable bodies undergo, without regard to the products. By fermentation, then, are now meant all the spontaneous changes which take place in vegetable substances after they are separated from the living plant. See CHEMISTRY.

Fermentation never takes place unless vegetable substances contain a certain portion of water, and unless they are exposed to a temperature at least above the freezing-point. When dry or freezing, many of them continue long without alteration. Hence we have an obvious method of preventing fermentation.

Sugar, gum, sarcocol, starch, indigo, wax, resins, camphor, caoutchouc, sandaracha, gum-resins, wood, and suber, though mixed with water, and placed in the most favourable temperature, show scarcely any tendency to change their nature. Oils absorb oxygen from the atmosphere, but too slowly to produce any intestine motion. Tan, some of the acids, and extract, are gradually decomposed; the surface of the liquid becomes mouldy, and an insipid sediment falls to the bottom: and when the process has once begun, it proceeds with great rapidity. Albumen and fibrina putrefy very quickly, but the products have not been ascertained; gluten gradually changes into a kind of cheese.

But it is when several of the vegetable principles are mixed together that the fermentation is most perceptible, and the change most remarkable. Thus when gluten is added to a solution of sugar in water, the liquid soon runs into vinegar, or in certain cases to alcohol and vinegar. When gluten is mixed with starch and water, alcohol and vinegar usually make their appearance; but the greatest part of the starch remains unaltered. It has been observed that certain substances are particularly efficacious in exciting fermentation in others. These substances have received the name of ferments.

But the phenomena of fermentation do not appear in their greatest perfection in our artificial mixtures of vegetable principles. Those complicated parts of plants in which various principles are already mixed by nature, especially the liquid parts, exhibit the finest specimens of it; such as the sap of trees, the juices of fruits, the decoctions of leaves, seeds, &c. It is from such natural mixtures that we obtain all the products of fermentation which mankind have applied to useful purposes; such as indigo, beer, bread, vinegar, wine, &c. We shall first treat of the fermentation which takes place during the making of bread; secondly, of the fermentation which produces intoxicating liquors; and thirdly, of the fermentation which produces vinegar. These are usually called the panary, vinous, and acetous fermentations.

FERMENTATION, *panary*. Simple as the manufacture of bread may appear to us who have always been accustomed to consider it as a common process, its discovery was probably the work of ages, and the result of the united efforts of men whose sagacity, had they lived in a more fortunate period of society, would have rendered them the rivals of Aristotle or of Newton.

The method of making bread similar to ours was known in the East at a very early period; but neither the precise time of the discovery, nor the name of the person who published it to the world, has been preserved. We are certain that the Jews were acquainted with it in the time of Moses, for in Exodus (ch. xii. 15.) we find a prohibition to use leavened bread during the celebration of the passover. It does not appear, however, to have been known to Abraham; for we hear, in history, of cakes frequently, but nothing of leaven. Egypt, both from the nature of the soil and the early period at which it was civilized, bids fairest for the discovery of making bread. It can scarcely be doubted that the Jews learned the art from the Egyptians. The Greeks assure us, that they were taught the art of making bread by the god Pan. We learn from Homer that it was known during the Trojan war. The Romans were ignorant of the method of making bread till the year 580 after the building of Rome, or 200 years before the commencement of the Christian æra. Since that period the art has never been unknown in the south of Europe: but it made its way to the north very slowly; and even at present in many northern countries, fermented bread is but very seldom used.

The only substance well adapted for making loaf-

bread, is wheaten flour, which is composed of three ingredients: namely, gluten, starch, and sweet mucous matter, which possesses nearly the properties of sugar, and which is probably a mixture of sugar and mucilage. It is to the gluten that wheat-flour owes its superiority to every other as the basis of bread. Indeed there are only two other substances at present known of which loaf-bread can be made: these are rye and potatoes. The rye loaf is by no means so well raised as the wheat loaf; and potatoes will not make bread at all without particular management. Potatoes, previously boiled and reduced to a very fine tough paste by a rolling-pin, must be mixed with an equal weight of potatoe-starch. This mixture, baked in the usual way, makes a very white, well-raised pleasant bread. We are indebted for the process to Mr. Parmentier. Barley-meal perhaps might be substituted for starch.

The baking of bread consists in mixing wheat-flour with water, and forming it into a paste. The average proportion of these is, two parts of water to three of flour. But this proportion varies considerably, according to the age and quality of the flour. In general, the older and the better the flour is, the greater is the quantity of water required. If the paste, after being thus formed, is allowed to remain for some time, its ingredients gradually act upon each other, and the paste acquires new properties. It gets a disagreeable sour taste, and a quantity of gas (probably carbonic acid gas) is evolved. In short, the paste ferments. These changes do not take place without water: that liquid, therefore, is a necessary agent. The gluten is altered, and probably acts on the starch; for if we examine the paste after it has undergone fermentation, the gluten is no longer to be found. If paste, after standing for a sufficient time to ferment, is baked in the usual way, it forms a loaf full of eyes like our bread, but of a taste so sour and unpleasant, that it cannot be eaten. If a small quantity of this old paste, or leaven as it is called, is mixed with new-made paste, the whole begins to ferment in a short time; a quantity of gas is evolved; but the glutinous part of the flour renders the paste so tough, that the gas cannot escape; it therefore causes the paste to swell in every direction: and if it is now baked into loaves, the immense number of air-bubbles imprisoned in every part renders the bread quite full of eyes, and very light. If the precise quantity of leaven necessary to produce the fermentation, and no more, has been used, the bread is sufficiently light, and has no unpleasant taste; but if too much leaven is employed, the bread has necessarily a bad taste; if too little, the fermentation does not come on, and the bread is too compact and heavy. To make good bread with leaven, therefore, is difficult.

The ancient Gauls had another method of fermenting bread. They formed their paste in the usual way; and, instead of leaven, mixed with it a little of the barm or yeast which collects on the surface of fermenting beer. This mixture produced as complete and as speedy a fermentation as leaven; and it had the great advantage of not being apt to spoil the taste of the bread. About the end of the 17th century, the bakers in Paris began to introduce this practice into their processes. The practice was discovered, and exclaimed against; the faculty of medicine, in 1688, declared it prejudicial to health; and it was not till after a long time that the bakers succeeded in convincing the public that bread baked with barm is superior to bread baked with leaven. In this country the bread has for these many years been fermented with barm.

With respect to the nature of the barm which produces these effects, Mr. Henry of Manchester has proved, by a number of very interesting experiments, that carbonic acid is capable of being employed in many cases with success as a substitute for barm. But the analysis of Mr. Westrum has demonstrated, that the barm which collects on the surface of beer is of a much more complicated nature. That celebrated chemist obtained from 15060 parts of good barm the following substances:

15	carbonic acid
10	acetic acid
45	malic acid
240	alcohol
120	extractive
240	mucilage
315	sugar
480	gluten.
13595	water
15060.	

Besides 69 parts of lime, 13 potass, some saclactic acid, and traces of phosphoric acid and silica.

But all these ingredients are not essential to barm. Westrum ascertained that the extractive, mucilage, sugar, and malic acid, are incable of producing fermentation; that barm, deprived of its gluten by filtration, loses the property of exciting fermentation in beer; that the gluten of wheat is capable alone of exciting a fermentation: and that gluten, mixed with a vegetable acid, answers all the purposes of a ferment. Hence it follows, that these bodies alone are essential to barm. But leaven is precisely such a compound.

After the bread has fermented, and is properly raised, it is put into the oven, which is previously heated, and allowed to remain till it is baked. The mean heat of an oven, as ascertained by Mr. Tillet, is 448. The bakers do not use a thermometer; but they judge that the oven has arrived at the proper heat when flour thrown on the floor of it becomes black very soon without taking fire. We see, from Tillet's experiment, that this happens at 448°.

When the bread is taken out of the oven, it is found to be lighter than when put in, as might naturally have been expected, from the evaporation of moisture which must have taken place at that temperature. Mr. Tillet, and the other commissioners who were appointed to examine this subject, in consequence of a petition from the bakers of Paris, found that a loaf, which weighed, before it was put into the oven, 4.625 lbs., after being taken out baked, weighed, at an average, only 3.813 lbs. or 0.812 lb. less than the paste. Consequently, 100 parts paste lose, at an average, 17.34 parts, or somewhat more than one-fifth, by baking. They found, however, that this loss of weight was by no means uniform, even with respect to those loaves which were in the oven at the same time, of the same form, and in the same place, and which were put in and taken out at the same instant. The greatest difference, in these circumstances, amounted to .2889, or 7.5 parts in the hundred, which is about one thirteenth of the whole.

This difference is very considerable: and it is not easy to say to what it is owing. It is evident, that if the paste has not all the same degree of moisture, and if the barm is not accurately mixed through the whole, if the fermentation of the whole is not precisely the same, that these differences must take place. Now it is needless to observe how difficult it is to perform all this completely. The French commissioners found, as might indeed have been expected, that, other things being equal, the loss of weight sustained is proportional to the extent of surface of the loaf, and to the length of time that it remains in the oven; that is, the smaller the extent of the external surface, or, which is the same thing, the nearer the loaf approaches to a globular figure, the smaller is the loss of weight which it sustains; and the longer it continues in the oven, the greater is the loss of weight which it sustains. Thus a loaf which weighed exactly 4 lbs. when newly taken out of the oven, being replaced as soon as weighed, lost, in ten minutes, .125lb. of its weight; and in ten minutes more it again lost .0625 lb.

Loaves are heaviest when just taken out of the oven; they gradually lose part of their weight, at least if not kept in a damp place, or wrapped round with a wet cloth. Thus Mr. Tillet found that a loaf of 4 lbs. after being kept for a week, wanted .3125, or nearly one-thirteenth, of its original weight.

When bread is newly taken out of the oven, it has a peculiar and rather pleasant smell, which it loses by keeping, unless its moisture is preserved by wrapping it round with a moist cloth, as it does also the peculiar taste by which new bread is distinguished. This shows us that the bread undergoes chemical changes; but what these changes are, or what the peculiar substance is to which the odour of bread is owing, is not known.

Bread differs very completely from the flour of which it is made, for none of the ingredients of the flour can now be discovered in it. The only chemist who has attempted an analysis of bread, is Mr. Geoffroy. He found that 100 parts of bread contained the following ingredients:

24.735 water
32.030 gelatinous matter, extracted by boiling water
39.843 residuum insoluble in water

96.608
3.392 loss

100.

Fermentation, *vinous*. Under this name are comprehended every species of fermentation which terminates in the formation of an intoxicating liquid. Now these liquids, though numerous, may all be comprehended under two heads; those obtained from the juices of plants, and those obtained from the decoctions of seeds. These two heads may be distinguished by the names of the most remarkable products belonging to each, viz. wine and beer. Let us take a view of each of these.

1. *Wine*.—There is a considerable number of ripe fruits from which a sweet liquor may be expressed, having at the same time a certain degree of acidity. Of such fruits we have the apple, the cherry, the gooseberry, the currant, &c. but by far the most valuable of these fruits is the grape, which grows luxuriantly in the southern parts of Europe. From grapes fully ripe may be expressed a liquid of a sweet taste, to which the name of must has been given. This liquid is composed almost entirely of five ingredients, viz. water, sugar, jelly, gluten, and a mixed acid, partly saturated with potass. The quantity of sugar which grapes fully ripe contain is very considerable; it may be obtained in crystals, by evaporating must to the consistence of syrup, separating the tartar which precipitates during the evaporation and then setting the must aside for some months. The crystals of sugar are gradually formed. From a French pint of must, the marquis de Bullion extracted half an ounce (French) of sugar, and $\frac{1}{16}$ ounce of tartar. According to Proust, the Muscadine grape contains ubout 30 per cent. of a peculiar species of sugar.

When must is put into the temperature of about 70°, the different ingredients begin to act upon each other, and what is called vinous fermentation commences. The phenomena of this fermentation are, an intestine motion in the liquid, it becomes thick and muddy, its temperature increases, and carbonic acid gas is evolved. In a few days the fermentation ceases, the thick part subsides to the bottom or rises to the surface, the liquid becomes clear, it has lost its saccharine taste and assumed a new one, its specific gravity is diminished; and, in short, it has become the liquid well known under the name of wine.

These changes are produced altogether by the mutual action of the substances contained in must; for they take place equally, and wine is formed equally well, in close vessels as in the open air.

If the must is evaporated to the consistency of a thick syrup, or to a rob, as the elder chemists termed it, the fermentation will not commence, though the proper temperature, and every thing else necessary to produce fermentation, should be present. But if this syrup is again diluted with water, and placed in favourable circumstances, it will ferment. The presence of water therefore is absolutely necessary for the existence of vinous fermentation. But, on the other hand, if the must is too much diluted with water, it either refuses to ferment altogether, or its fermentation is very languid.

If the juice of those fruits which contain but little sugar, as currants, is put into a favourable situation, fermentation indeed takes place, but so slowly, that the product is not wine but vinegar; but if a sufficient quantity of sugar is added to these very juices, wine is readily produced. No substance whatever can be made to undergo vinous fermentation, and to produce wine, unless sugar is present. Sugar therefore is absolutely neccessary for the existence of vinous fermentation; and we are certain that it is decomposed during the process, for no sugar can be obtained from properly fermented wine. It has been sufficiently demonstrated by the experiments of Macquer, and the observations of Chaptal, that the strength of the wine is always proportional to the quantity of sugar contained in the must. From the experiments of Bullion we learn, that when must contains little sugar, the fermentation is rapid, but the product yields little alcohol. When the proportion of sugar is great, the fermentation is slow, but the product yields much alcohol.

All those juices of fruits which undergo the vinous fer-

mentation, either with or without the addition of sugar, contain an acid. The apple, for instance, contains malic acid; the lemon, citric acid; the grape, tartaric and malic acids. The marquis de Bullion has ascertained that must will not ferment if all the tartar which it contains is separated from it, but it ferments perfectly well on restoring that salt. The same chemist ascertained, that the strength of wine is considerably increased by adding tartar and sugar to the must. We may conclude from these facts, that the presence of a vegetable acid is necessary for the commencement of the vinous fermentation. It deserves attention that Bullion obtained more tartar from verjuice than from wine; and he observed that the more the proportion of sugar in grapes increased, the more that of tartar diminished.

All the juices of fruits which undergo the vinous fermentation contain an extractive matter, composed of what Deyeux has called the sweet principle. This substance has not been examined with much precision; but it seems to consist of mucilage, gluten, and extract. Now the presence of this substance is also necessary for the commencement of fermentation. For sugar, though diluted with water, and mixed with a vegetable acid, refuses to ferment, unless some mucilaginous matter is added. Bullion found that sugar, tartar, and water, did not ferment; but on adding vine-leaves the fermentation became rapid. And Bergman found that sugar dissolved in four times its weight of water, and mixed with yeast, undergoes the vinous fermentation; and the experiment has been often repeated since. In both these cases the ferment appears to be gluten.

Thus we see, that for the production of wine, a certain temperature, a certain portion of water, sugar, a vegetable acid, and gluten, are necessary. M. Lavoisier found that sugar would not ferment unless dissolved in at least four times its weight of water. This seems to indicate that the particles of sugar must be removed to a certain distance from each other before the other ingredients can decompose them.

When all these substances exist in must in proper proportions, the fermentation commences very speedily, provided the liquid is placed in a proper temperature; and its rapidity (other things remaining the same) is always proportioned to the quantity of liquid exposed at once to fermentation. The heat evolved is always proportioned to the rapidity of the process, and indeed may be looked upon as the great cause of that rapidity. According to Chaptal, the temperature during fermentation is never lower than 60°, and sometimes it is as high as 95.

During the fermentation, the quantity of sugar is constantly diminishing; and when the process is completed, the whole of the sugar is decomposed. The liquid has become more fluid, specifically lighter, and has acquired a vinous taste, owing to the formation of alcohol. Whether the other substances which constitute a part of the must have undergone any change, or whether they have merely contributed to the decomposition of the sugar, is not precisely known. The experiments of Lavoisier, to whom we are indebted for the first precise explanation of fermentation, render the second supposition most probable. From these experiments it follows that the sugar is divided into two portions; one portion separates in the form of carbonic acid, and the other, containing a great excess of hydrogen, remains under the form of alcohol. This alcohol is combined with the colouring matter, and with the acids of the wine, so intimately, that it can only be separated by distillation. The carbonic acid carries along with it a certain portion of alcohol, as was pointed out some time ago by Chaptal. The extractive matter separates, either precipitating to the bottom or swimming on the surface.

It seems more than probable, from the experiments of Bullion and Chaptal, that the tartaric acid is partly decomposed during the fermentation, and that a portion of malic acid is formed. The process, therefore, is more complicated than was suspected by Lavoisier. It is obviously analogous to combustion, as is evident from the evolution of caloric and the formation of carbonic acid, which is a product of combustion. Proust has ascertained, that during the fermentation not only carbonic acid, but azotic gas also, is disengaged. This is a demonstration, that all the constituents of must are concerned; for sugar does not contain that principle.

After the fermentation has ceased, the liquor is put into casks, where the remainder of the sugar is decomposed by a slow fermentation; after which the wine, decanted off from the extractive matter, is put up in bottles.

The properties of wine differ very much from each other, according to the nature of the grapes from which the must was extracted, and according to the manner in which the process was conducted. These differences are too well known to require a particular description. But all wines contain less or more of the following ingredients, not to mention water, which constitutes a very great proportion of every wine.

1. *An acid.*—All wines give a red colour to paper stained with turnsole, and of course contain an acid. Chaptal has ascertained that the acid found in greatest abundance in wine is the malic, but he found traces also of citric acid, and it is probable that wine is never entirely destitute of tartar. All wines which have the property of frothing when poured into a glass, contain also carbonic acid, to which they owe their briskness. This is the case with champaign. These wines are usually weak; their fermentation proceeds slowly, and they are put up in close vessels before it is over. Hence they retain the last portions of carbonic acid that have been evolved.

2. *Alcohol.*—All wine contains less or more of this principle, to which it is indebted for its strength; but in what particular state of combination it exists in wine, cannot be easily ascertained. It is undoubtedly intimately combined with the other component parts of wine; as Fabroni has shown that it cannot be separated by saturating the wine with dry carbonat of potass, though a very small portion of alcohol, added on purpose to wine, may be easily separated by means of that salt. But as alcohol separates along with the carbonic acid during the fermentation, we can scarcely doubt that it has been formed. When wine is distilled, the alcohol readily separates. The distillation is usually continued as long as the liquid which comes over is inflammable. The quantity obtained varies according to the wine, from a fourth part to a fourteenth part of the wine dis-

tilled. The spirit thus obtained is well known under the name of brandy. Bullion has observed, that when wine is distilled new, it yields more alcohol than if it is allowed to get old. What remains after this distillation is distinguished in France by the name of vinasse. It consists of tartar, &c. and when evaporated to dryness, and subjected to combustion, yields potass.

3. *Extractive matter.*—This matter exists in all wines; but its proportion diminishes according to the age of the wine, as it gradually precipitates to the bottom.

4. Every wine is distinguished by a peculiar flavour and odour, which probably depend upon the presence of a volatile oil, so small in quantity that it cannot be separated.

5. The colouring matter of wine is originally contained in the husk of the grape, and is not dissolved till the alcohol is developed. This matter is analogous to the other colouring matters of plants; a set of bodies possessed of remarkable properties, but too little examined hitherto to be capable of a clear explanation. This colouring matter precipitates when the wine is exposed to the heat of the sun. It sometimes also precipitates in old wine, and it may be easily separated by pouring lime-water into wine.

If wine be exposed to the heat of the sun during the summer, the colouring matter is detached in a pellicle, which falls to the bottom: when the vessel is opened, the discolouring is more speedy, and it is effected in two or three days during the summer. The wine thus deprived of its colour is not perceptibly weakened.

The following table, containing the different substances which Neumann extracted from various wines, is worth preserving.

A quart of	Highly rectified spirit.			Thick, oily, unctuous, resinous matter.			Gummy and tartarous matter.			Water.			
	oz.	d.	gr.	oz.	d.	gr.	oz.	dr.	gr.	lb.	oz.	dr.	gr.
Aland	1	6	0	3	2	0	1	5	0	2	5	3	0
Alicant	3	6	0	6	0	20	0	1	40	2	2	6	0
Burgundy	2	2	0	0	4	0	0	1	40	2	9	0	20
Carcassone	2	6	0	0	4	10	0	1	20	2	8	4	30
Champagne	2	5	20	0	6	40	0	1	0	2	8	3	0
French	3	0	0	0	6	40	0	1	0	2	8	0	20
Frontignac	3	0	0	3	4	0	0	5	20	2	4	6	30
Vin grave	2	0	0	0	6	0	0	2	0	2	9	0	0
Hermitage	2	7	0	1	2	0	0	1	40	2	7	5	20
Madeira	2	3	0	3	2	0	2	0	0	2	4	3	0
Malmsey	4	0	0	4	3	0	2	3	0	2	1	2	0
Vino de monte Pulciano	2	6	0	0	3	0	0	2	40	2	8	0	20
Moselle	[illegible]	2	0	0	4	20	0	1	30	2	9	0	10
Muscadine	3	0	0	2	4	0	1	0	0	2	5	4	0
Neufchatel	3	2	0	4	0	0	1	7	0	2	2	7	0
Palm sec	2	3	0	2	4	0	4	4	0	2	2	5	0
Pontac	2	0	0	0	5	20	0	2	0	2	9	0	40
Old Rhenish	2	0	0	1	0	0	0	2	20	2	8	5	40
Rhenish	2	2	0	0	3	20	0	1	34	2	9	1	6
Salamanca	3	0	0	3	4	0	2	0	0	2	3	4	0
Sherry	3	0	0	3	0	0	2	2	0	2	0	6	0
Spanish	1	2	0	2	4	0	9	4	0	1	10	6	0
Vino Tinto	3	0	0	6	4	0	1	6	0	2	0	6	0
Tokay	2	2	0	4	3	0	5	0	0	2	0	3	0
Tyrol red wine	1	4	0	1	2	0	0	4	0	2	8	6	0
Red wine	1	6	0	0	4	40	0	2	0	2	9	3	20
White	2	0	0	0	7	0	0	3	0	2	7	0	0

To this head belong not only common wine, but all the intoxicating liquors made from vegetable juices; as cyder from apples, perry from pears, currant wine, &c. likewise the liquor made from the juice of the sugar-cane, the sugar-maple, &c.

II. *Beer.*—The method of making beer, though undoubtedly not so obvious as that of making wine, was, notwithstanding, known in the most remote ages. Whatever grain is employed, the process is nearly the same. The barley is steeped in water for about 60 hours, in order to saturate it with the liquid. (See MALTING.) It ought then to be removed as speedily as possible, otherwise the water dissolves and carries off the most valuable part of the grain. The barley is then to be laid in a heap for 24 hours; heat is evolved, oxygen gas absorbed, carbonic acid gas emitted, and germination commences with the shooting forth of the radicle. It is then spread upon a cool floor, dried slowly, and is afterwards known by the name of malt.

Malt, previously ground to a coarse powder, is to be infused in a sufficient quantity of pure water, of the temperature of 160° for an hour. The infusion is then to be drawn off, and more water may be added, at a higher temperature, till all the soluble part of the malt is extracted. This infusion is known by the name of wort. It has a sweet taste, and contains a quantity of saccharine, and doubtless also of gelatinous matter. See BREWING.

The wort is immediately conveyed to a boiler, where it is boiled with hops, or some other equivalent bitter. It is then put into large fermenting vats.

When wort is placed in the temperature of about 60°, fermentation gradually takes place in it, and the very same phenomena appear which distinguish the production of wine. The fermentation of wort then, is nothing but a particular case of the vinous fermentation. But wort does not ferment so well, nor so soon, nor does it produce nearly so great a quantity of good fermented liquor, as when yeast is added to it. The reason of which is, probably, that the fermentation does not commence till an acid is generated in the wort, and before that happens part of the saccharine contents are decomposed; whereas the yeast adds an acid, or at least something equivalent to it, at once.

Wort ferments in close vessels, as Mr. Collier ascertained by experiment, equally well as in the open air. The decomposition, therefore, is produced entirely by the substances contained in the wort, without the addition of any thing from the air. The quantity of beer produced in close vessels is much greater than when the process takes place in the open air. The reason of which is, that in the open air the beer gradually evaporates during the fermentation. Thus M. Collier found that 11 quarts, $3\frac{1}{2}$ oz. fermented in open vessels, lost in 12 days 40 oz. whereas an equal weight, fermented in close

vessels, lost only 8 oz. in the same time. Yet the quality of the beer was the same in each; for equal quantities of both, when distilled, yielded precisely the same portion of alcohol.

During the fermentation a quantity of carbonic acid gas is constantly disengaged, not in a state of purity, but containing, combined with it, a portion of the wort; and if this gas is made to pass through water, it will depose wort, which may be fermented in the usual manner.

When beer is distilled, alcohol is obtained, and the residuum is an acid liquor, the nature of which is still unknown. The theory of beer is so obviously the same with that of wine, that it requires no additional explanation.

Fermentation, *acetous*. If wine or beer is kept in a temperature between 70° and 90°, it gradually becomes thick, its temperature augments, filaments are seen moving through it in every direction, and a kind of hissing noise may be distinguished. These intestine motions gradually disappear, the filaments attach themselves to the sides and bottom of the vessel, and the liquor becomes transparent. But it has now lost its former properties, and is converted into acetous acid. This intestine decomposition has been long distinguished by the name of acetous fermentation, because its product is acetic acid. That this fermentation may take place, certain conditions must be attended to. The most important of these will appear from the following observations:

1. Neither pure alcohol, nor alcohol diluted with water, is susceptible of this change. The weaker the wine or the beer on which the experiment is made, the more readily it is converted into vinegar; the stronger they are, they resist the change with the greatest obstinacy. But it results from the experiments of Beecher, that strong wines, when they are made to undergo the acetous fermentation, yield a much better and stronger vinegar than weak wines. Hence it follows that alcohol, though of itself it refuses to undergo the change, yet when other bodies are present which readily ferment, it is decomposed during the process, and contributes to the formation of the acetic acid.

2. Wine, entirely deprived of extractive matter either by spontaneous deposition or by clarification, does not undergo the acetous fermentation, unless some mucilaginous matter is mixed with it. Chaptal exposed old wine destitute of this matter, in open bottles, to the greatest summer-heat of Montpelier for 40 days, and yet it did not become sour; but upon adding some vine-leaves to the same wine, it became acid in a few days.

3. Wine never becomes sour, provided it is completely deprived of all access to atmospheric air. The reason is, that during the acetous fermentation, oxygen is absorbed from the atmosphere in abundance; and unless that absorption can take place, no vinegar is ever formed. Hence the reason that wine or beer is more apt to become sour after the cork has been drawn, and still more apt when part has been poured out of the bottle.

4. A pretty high temperature is necessary for the commencement of the acetous fermentation. Wine or beer (unless very weak) scarcely becomes sour under the temperature of 65° or 70°. The fermentation is very apt to commence when the temperature suddenly rises. Hence wine and beer are more apt to become sour at certain seasons of the year than at others.

5. When the acetous fermentation is completed, the whole of the malic acid originally contained in the wine has disappeared as well as the alcohol. We must conclude, therefore, that they have both been converted into acetic acid. Part of the extractive matter has also undergone the same change, and seems indeed to have been the substance that first began the absorption of oxygen. Part of it is deposited in the state of flakes; part remains in solution, and disposes the vinegar to decomposition. Vinegar also contains a little tartar, and probably also citric acid. Malic acid is also found in new vinegar; a proof that this part of the wine is the last to undergo the acetous fermentation.

6. Acetic acid is formed in many other cases of the decomposition of vegetables besides the acetous fermentation. These have been pointed out with much ingenuity by Vauquelin and Fourcroy. They may be reduced under three heads: 1st. When sugar, gum, tartar, wood, &c. are distilled in a retort, or even burnt in the open fire, acetic acid separates in combination with an empyreumatic oil which distinguishes its odour. Hence it was mistaken for other acids, and distinguished by the names of pyromucous, pyrolignous, pyrotartarous acids, till its real nature was ascertained by these distinguished chemists. 2dly. When concentrated sulphuric acid is poured upon the same vegetable bodies, they are decomposed in a very different manner, being converted into water, charcoal, and acetic acid. 3dly. Acetic acid is evolved in considerable quantity during the spontaneous decomposition of urine, and some other animal substances. Thus it appears, that the component parts of this important acid are extremely apt to combine together in those proportions which constitute it.

Fermentation, *putrid*, as it has been termed by the old chemists, is that process which converts vegetable and animal matters into soil. It is, however, not fermentation, but a different process, wanting almost all the characteristics of fermentation, and therefore will be treated separately under the article Putrefaction.

FERN. See Felix.

FERRARIA, a genus of the triandria order, in the gynandria class of plants, and in the natural method ranking under the sixth order, ensatæ. The spathæ are uniflorous; the petals six in number, and wavingly curled; the stigmata cucullated or cowled; the capsule is trilocular, inferior. There are two species, natives of the Cape of Good Hope and Mexico. There is a great singularity in the root of one of these species, that it vegetates only every other year, and sometimes every third year; in the intermediate time it remains inactive, though very sound and good.

FERRET, in zoology. See Mustela.

FERRUGINOUS, any thing partaking of iron, or that contains particles of that metal. It is particularly applied to certain mineral springs, whose waters are impregnated with the particles of iron generally termed chalybeats. See Mineral Waters.

FERRY, is a liberty by prescription, or the king's grant, to have a boat for passage upon a river, for car-

riage of horses and men, for reasonable toll. Savil, 11 & 14. The owner of a ferry cannot suppress that ferry, and put up a bridge in its place, without a licence. Show. 243. 257.

FERRUM. See IRON, CHEMISTRY, &c.

FERULA, *fennel giant*, a genus of the digynia order, in the pentandria class of plants, and in the natural method ranking under the 45th order, umbellatæ. The fruit is oval, compressed plane, with three striæ on each side. There are nine species, all of them herbaceous perennials, rising from three to ten or twelve feet high, with yellow flowers. They are propagated by seeds, which should be sown in autumn, and when planted out, ought to be four or five feet distant from each other, or from any other plants; for no other will thrive under their shade. The drug assafoetida is obtained from a species of ferula, though not peculiarly; being also produced by some other plants. See Plate LX. Nat. Hist. fig. 206.

FERULA, in the ancient Eastern church, signified a place separated from the church, wherein the audientes were kept, as not being allowed to enter the church; whence the name of the place, the persons therein being under penance or discipline. This word was sometimes used to denote the prelate's crozier or staff.

FESSE, in heraldry, one of the nine honourable ordinaries, consisting of a line drawn directly across the shield, from side to side, and containing the third part of it, between the honour-point and the nombril.

FESTI DIES, in Roman antiquity, certain days in the year devoted to the honour of the gods. Numa, when he distributed the year into twelve months, divided the same into the dies festi, dies profesti, and dies intercisi. The festi were again divided into days of sacrifices, banquets, games, and feriæ.

The profesti were those days allowed to men for the administration of their affairs, whether of a public or private nature; these were divided into fasti, comitales, comperendini, stati, and præliares.

The intercisi were days common both to gods and men, some parts of which were allotted to the service of the one, and some to that of the other.

FESTINO, in logic, the third mood of the second figure of syllogism, the first proposition whereof is an universal negative, the second a particular affirmative, and the third a particular negative; as in the following example:

FES No bad man can be happy:
TI Some rich men are bad men:
NO *Ergo*, some rich men are not happy.

FEUD-BOTE, a recompence for being concerned in a feud or quarrel.

FEVER, *febris*, in medicine, a disease, or rather class of diseases, whose characteristic is a preternatural heat felt through the whole body, or at least the principal parts of it. See MEDICINE.

FIBRARIÆ, a class of fossils. See ASBESTOS.

FIBRE, in anatomy, a perfect simple body, or at least as simple as any thing in the human structure, being fine and slender like a thread, and serving to form other parts. Hence some fibres are hard, as the bony ones; and others soft, as those destined for the formation of all the other parts.

FIBRINA, is that substance which constitutes the fibrous part of the muscles of animals. If a quantity of blood, newly drawn from an animal, be allowed to remain at rest for some time, a thick red clot gradually forms in it, and subsides. Separate this clot from the rest of the blood, put it into a linen cloth, and wash it repeatedly in water till it ceases to give out any colour or taste to the liquid; the substance which remains after this process is denominated fibrina. It has been long known to physicians under the name of the fibrous part of the blood, but has not till lately been accurately described.

It may be procured also from the muscles of animals. Mr. Hatchett, to whom we are indebted for a very interesting set of experiments on this substance, cut a quantity of lean beef into small pieces, and macerated it in water for 15 days, changing the water every day, and subjecting the beef to pressure at the same time, in order to squeeze out the water. As the weather was cold, it gave no signs of putrefaction during this process. The shreds of muscle, which amounted to about three pounds, were now boiled for five hours every day for three weeks in six quarts of fresh water, which was regularly changed every day. The fibrous part was now pressed, and dried by the heat of a water-bath. After this treatment it might be considered as fibrina nearly as pure as it can be obtained.

Fibrina is of a white colour, has no taste nor smell; and is not soluble in water nor in alcohol. When newly extracted from blood, it is soft and elastic, and resembles very much the gluten of vegetables. Its colour deepens very much in drying. That which is extracted from muscle by boiling and maceration has a certain degree of transparency, and is not ductile but brittle. Its colour does not deepen nearly so much as the fibrina from blood.

It undergoes no change, though kept exposed to the action of air; neither does it alter speedily, though kept covered with water. Mr. Hatchett kept a quantity of the fibrina which he had prepared from beef moistened with water during the whole month of April; it acquired a musty but not a putrid smell, neither were the fibres reduced to a pulpy mass. Even when kept two months under water, it neither became putrid, nor was converted into the fatty matter obtained by macerating recent muscle.

When fibrina is exposed to heat, it contracts very suddenly, and moves like a bit of horn, exhaling at the same time the smell of burning feathers. In a stronger heat it melts. When exposed to destructive distillation it yields water, carbonat of ammonia, a thick heavy fetid oil, traces of acetic acid, carbonic acid, and carbureted hydrogen gas. The charcoal, as Mr. Hatchett ascertained, is more copious than that left by gelatine or albumen. It is very difficult to incinerate, owing to the presence of phosphat of soda and some phosphat of lime, which form a glassy coat on the surface. A considerable proportion of carbonat of lime also remains after the incineration of the charcoal.

Acids dissolve fibrina with considerable facility. Sulphuric acid gives it a deep-brown colour, charcoal is precipitated, and acetic acid formed. Muriatic acid dissolves it, and forms with it a green-coloured jelly. The acetic, citric, oxalic, and tartaric acids, also dissolve it by the assistance of heat; and the solutions, when concen-

trated, assume the appearance of jelly. Alkalies precipitate the fibrina from acids in flakes, soluble in hot water, and resembling gelatine in its properties.

Diluted nitric acids occasions the separation of a considerable portion of azotic gas, as was first observed by Berthollet. Mr. Hatchett steeped a quantity of fibrina in nitric acid, diluted with thrice its weight of water. for 15 days. The acid acquired a yellow tinge, and possessed all the properties of the nitric solution of albumen. The fibrina thus treated dissolved in boiling water, and when concentrated by evaporation, became a gelatinous mass, soluble in hot water, and precipitated by tan and nitromuriat of tin, and therefore possessing the properties of gelatine. Ammonia dissolves the greater part of the fibrina after it has been altered by nitric acid. The solution is of a deep orange-colour, similar to the solution of albumen treated in the same way. Boiling nitric acid dissolves fibrina, except some fatty matter which swims on the surface. The solution resembles that of albumen, except that ammonia throws down a white precipitate, consisting chiefly of oxalat of lime. During the solution, prussic acid comes over, and carbonic acid gas mixed with nitrous gas; a considerable portion of oxalic acid is formed, besides the fatty matter which swims. It is probable that this last substance does not differ much from the substance formed by causing nitric acid to act upon the muscles of animals, which the French chemists have distinguished by the name of adipocire.

The alkalies, while diluted, have but little effect upon fibrina; but when concentrated potass or soda is boiled upon it, a complete solution is obtained of a deep-brown colour, possessing the properties of soap. During the solution, ammonia is disengaged. When the solution is saturated with muriatic acid, a precipitate is obtained similar to that from animal soap, except that it sooner becomes hard and soapy when exposed to the air.

The earths, as far as is known, have little or no action on fibrina. Neither has the action of the metallic oxides and salts been examined.

Fibrina is insoluble in alcohol, ether, and oils. The effect of other reagents on it has not been examined.

From the properties above detailed, fibrina appears to be composed of the same constituents as albumen and gelatine; but it probably contains more carbon and azote, and possibly less oxygen. The close resemblance which it bears to albumen is very obvious from the experiments of Mr. Hatchett just detailed. Nitric acid converts both into gelatine, and alkalies convert both into a species of oil. Now as all the soft parts of animals consist of combinations of these three genera, it follows, as Mr. Hatchett has observed, that all the soft parts of animals may be either converted into gelatine or animal soap, both substances of the highest importance.

Fibrina exists only in the blood and the muscles of animals; but it is a genus which includes as many species as there are varieties in the muscles of animals, and the great variety of these substances is well known. The muscles of fish, of fowl, and of quadrupeds, bear scarcely any resemblance to each other.

A substance exactly resembling the fibrina, as it exists in the blood, has been detected by Vauquelin in the juice of the papaw-tree; the same juice which contained

albumen in such plenty. Fibrina then must be ranked among vegetable substances.

When the juice of the papaw is treated with water, the greatest part dissolves; but there remains a substance insoluble, which has a greasy appearance. It softens in the air, and becomes viscid, brown, and semi-transparent. When thrown on burning coals it melted, let drops of grease exude, emitted the noise of meat roasting, and produced a smoke which had the odour of fat volatilized. It left behind it no residue. This substance was the fibrina. The resemblance between the juice of the papaw and animal matter is so close, that we should almost be tempted to suspect some imposition, was not the evidence that it is really the juice of a tree quite unexceptionable.

The properties of fibrina are the following:

1. It is tasteless, fibrous, elastic, and resembles gluten.
2. It is insoluble in water and in alcohol.
3. It is not dissolved by alkalies.
4. But acids dissolve it without difficulty.
5. With nitric acid it gives out much azotic gas.
6. When distilled it yields much carbonat of ammonia and oil.
7. It soon putrifies when kept moist, becomes green, but does not acquire any resemblance to cheese. See Gluten.

FIBROLETE, a mineral, first observed by Bournon, in the matrix of the imperfect corundum. Colour white or dirty grey; specific gravity 3 214; texture fibrous; cross fracture compact; internal lustre glossy; infusible by the blowpipe. Usually in shapeless fragments. It is composed of

58.25	alumina
38.00	silica
3.75	a trace of iron, and loss.
100.00	

FIBULA, in anatomy, the outer and smaller bone of the leg.

FICTION of law, is allowed of in several cases; but it must be framed according to the rules of law; and there ought to be equity and possibility in every legal fiction.

Fictions were invented to avoid inconvenience; and it is a maxim invariably observed, that no fiction shall extend to work an injury, its proper operation being to prevent a mischief, or remedy an inconvenience, that might result from the general rule of law. 3 Black. 434.

All fictions of law are to certain respects and purposes, and extend only to certain persons; as the law supposes the vouchee to be tenant of the land, where in rei veritate he is not; but this is as to the demandant himself, and to enable him to do things as to the demandant, and which the demandant may do to him; and therefore a fine levied by vouchee to the demandant, or fine or release from the defendant to the vouchee, is good; but fine levied by the vouchee to a stranger, or lease made to him by a stranger, is void. 3 Rep. 29. See Fine, and Recovery.

FICUS, a genus of the triœcia order, in the polygamia class of plants, and in the natural method ranking

under the 53d order, scabridæ. The receptacle is common, turbinated, carnous, and connivent; inclosing the florets either in the same or in a distinct one. The male calyx is tripartite: no corolla; three stamina: the female calyx is quinquepartite; no corolla; one pistil; and one seed. There are 56 species, of which the following are the most remarkable.

1. Ficus indica, or banian-tree, is a native of several parts of the East Indies. It has a woody stem, branching to a great height and vast extent, with heart-shaped entire leaves ending in acute points. This tree is beautifully described by Milton in Paradise Lost, book ix. l. 1100.

Indeed the banian-tree, or Indian fig, is perhaps the most beautiful of nature's productions in that genial climate, where she sports with so much profusion and variety. Some of these trees are of amazing size and great extent, as they are continually increasing, and, contrary to most other things in animal and vegetable life, seem to be exempted from decay. Every branch from the main body throws out its own roots; at first, in small tender fibres, several yards from the ground: these continually grow thicker until they reach the surface; and there striking in, they increase to large trunks, and become parent trees, shooting out new branches from the top: these in time suspend their roots, which, swelling into trunks, produce other branches; thus continuing in a state of progression as long as the earth, the first parent of them all, contributes her sustenance. The Hindoos are peculiarly fond of the banian-tree; they look upon it as an emblem of the Deity, from its long duration, its out-stretching arms, and overshadowing beneficence; they almost pay it divine honours, and

"Find a fane in every sacred grove."

Near these trees the most esteemed pagodas are generally erected; under their shade the Brahmins spend their lives in religious solitude; and the natives of all casts and tribes are fond of recreating in the cool recesses, beautiful walks, and lovely vistas of this umbrageous canopy, impervious to the hottest beams of a tropical sun.

A remarkable large tree of this kind grows on an island in the river Nerbedda, ten miles from the city of Baroche, in the province of Guzerat, a flourishing settlement lately in the possession of the East India company, but ceded by the government of Bengal, at the treaty of peace concluded with the Mahrattas in 1783, to Mahdajee Scindia, a Mahratta chief. It is distinguished by the name of Cubbeer Burr, which was given it in honour of a famous saint. It was once much larger than at present; but high floods have carried away the banks of the island where it grows, and with them such parts of the tree as had thus far extended their roots; yet what remains is about 2000 feet in circumference, measured round the principal stems; the overhanging branches, not yet struck down, cover a larger space. The chief trunks of this single tree (which in size greatly exceed our English elms and oaks) amount to 350; the smaller stems, forming into stronger supporters, are more than 3000; and every one of these is casting out new branches, and hanging roots, in time to form trunks, and become the parents of a future progeny. Cubbeer Burr is famed throughout Hindostan for its great extent and surpassing beauty: the Indian armies generally encamp around it, and at stated seasons, solemn jatarras, or Hindoo festivals, are held there, to which thousands of votaries repair from various parts of the Mogul empire. It is said that 7000 persons find ample room to repose under its shade. The English gentlemen, on their hunting and shooting parties, used to form extensive encampments, and spend weeks together under this delightful pavilion; which is generally filled with green wood-pigeons, doves, peacocks, and a variety of feathered songsters; crowded with families of monkeys performing their antic tricks, and shaded by bats of a large size, many of them measuring upwards of six feet from the extremity of one wing to the other. This tree not only affords shelter, but sustenance, to all its inhabitants, being covered amidst its bright foliage with small figs of a rich scarlet, on which they all regale with as much delight as the lords of creation on their more various and costly fare.

2. The sycamorus, or sycamore of scripture. According to Mr. Hasselquist, this is a huge tree, the stem being often 50 feet round. The fruit is pierced in a remarkable manner by an insect. There is an opening made in the calyx near the time the fruit ripens, which is occasioned in two different ways: 1. When the squamæ, which cover the calyx, wither and are bent back, which, however, is more common to the carica than the sycamore. 2. A little below the scales, on the side of the flower-cup, there appears a spot before the fruit is ripe; the fruit in this place is affected with a gangrene which extends on every side, and frequently occupies a finger's breadth. It withers; the place affected becomes black; the fleshy substance in the middle of the calyx, for the breadth of a quill, is corroded; and the male blossoms, which are nearest to the bare side, appear naked, opening a way for the insect, which makes several furrows in the inside of the fruit, but never touches the stigmata, though it frequently eats the germen. The wounded or gangrenous part is at first covered or shut up by the blossoms; but the hole is by degrees opened and enlarged of various sizes in the different fruits; the margin and sides being always gangrenous, black, hard, and turned inwardly. The same gangrenous appearance is also found near the squamæ, after the insect has made a hole in that place. The tree is very common in the plains and fields of Lower Egypt. It buds in the end of March, and the fruit ripens in the beginning of June. It is wounded or cut by the inhabitants at the time it buds; for without this precaution they say it would not bear fruit.

3. The carica, or common fig, with an upright stem branching 15 or 20 feet high, with large palmated or hand-shaped leaves. Of this there are a number of varieties; as the common fig, a large, oblong, dark purplish-blue fruit, which ripens in August either on standards or walls, and the tree carries a great quantity of fruit. The brown or chesnut fig; a large, globular, chesnut-coloured fruit, having a purplish delicious pulp, ripening in July and August. The black Ischia fig; a middle-sized, shortish, flat-crowned, blackish fruit, having a bright pulp, ripening in the middle of August. The green Ischia fig; a large, oblong, globular-headed, greenish fruit, slightly stained by the pulp to a reddish-brown co-

lour, ripens in the end of August. The brown Ischia fig; a small, pyramidal, brownish-yellow fruit, having a purplish very rich pulp, ripening in August and September. The Malta fig; a small flat-topped brown fruit, ripening in the middle of August or beginning of September. The round brown Naples fig; a globular, middle-sized, light-brown fruit, and brownish pulp, ripe by the end of August. The long brown Naples fig; a long dark-brown fruit, having a reddish pulp, ripe in September. The great blue fig; a large blue fruit, having a fine red pulp. The black Genoa fig; a large, pear-shaped, black-coloured fruit, with a bright red pulp, ripe in August.

Culture.—The last species is that most frequently cultivated in this country, and the only one which does not require to be kept in a stove. It may be propagated either by suckers arising from the roots, by layers, or by cuttings. The suckers are to be taken off as low down as possible; trim off any ragged part at bottom, leaving the tops entire, especially if for standards, and plant them in nursery lines at two or three feet distance from each other, or they may at once be planted where they are to remain, observing, that if they are designed for walls or espaliers, they may be headed to six or eight inches in March, the more effectually to force out lateral shoots near the bottom; but if intended for standards, they must not be topped, but trained with a stem, not less than 15 or 18 inches for dwarf-standards, a yard for half-standards, and four, five, or six feet for full standards. They must then be suffered to branch out to form a head; observing that whether against walls, espaliers, or standards, the branches or shoots must never be shortened, unless to procure a necessary supply of wood: for the fruit is always produced on the upper parts of the young shoots; and if these are cut off, no fruit can be expected. The best season for propagating these trees by layers is in autumn; but it may be also done any time from October to March or April. Choose the young pliable lower shoots from the fruitful branches; lay them in the usual way, covering the body of the layers three or four inches deep in the ground, keeping the top entire, and as upright as possible, and they will be rooted and fit to separate from the parent in autumn; when they may be planted either in the nursery, or where they are to remain, managing them as above directed. The time for propagating by cuttings is either in autumn at the fall of the leaf, or any time in March. Choose well-ripened shoots of the preceding summer, short, and of robust growth, from about 12 to 15 inches long, having an inch or two of the two-years wood at their base, the tops left entire, and plant them six or eight inches deep, in a bed or border of good earth, in rows two feet asunder; and when planted in autumn, it will be eligible to protect their tops in time of hard frost, the first winter, with any kind of long loose litter.

That part of the history of the fig-tree, which for many ages was so enigmatical, namely, the caprification, as it is called, is particularly worthy of attention, not only as a singular phænomenon in itself, but as it has furnished one of the most convincing proofs of the reality of the sexes in plants. In brief it is this: the flowers of the fig-tree are situated within a pulpy receptacle, which we call the fig or fruit; of these receptacles, in the wild fig-tree, some have male flowers only, and others have male and female, both distinct, though placed in the same receptacle. In the cultivated fig, these are found to contain only female flowers, which are fecundated by means of a kind of gnat bred in the fruit of the wild fig-trees, which pierces that of the cultivated, in order to deposit its eggs within; at the same time diffusing within the receptacle the farina of the male flowers. Without this operation the fruit may ripen, but no effective seeds are produced. Hence the garden fig can only be propagated by layers and cuttings in those countries where the wild fig is not known. The process of thus ripening the fruit, in the Oriental countries, is not left to nature, but is managed with great art, and different degrees of dexterity, so as to reward the skilful husbandman with a much larger increase of fruit than would otherwise be produced. A tree of the same size which in Provence, where caprification is not practised, may produce about 25 pounds of fruit, will by that art, in the Grecian islands, bring ten times that quantity.

Figs are a considerable article in the materia medica, chiefly employed in emollient cataplasms and pectoral decoctions. The best are those which come from Turkey. Many are also brought from the south of France, where they prepare them in the following manner. The fruit is first dipped in scalding-hot ley made of the ashes of the fig-tree, and then dried in the sun. Hence these figs stick to the hands, and scour them like lixivial salts; and for the same reason they purge gently, without griping. They are moderately nutrimental, grateful to the stomach, and easier to digest than any other of the sweet fruits. They have been said to produce lice when eaten as a common food; but this seems to be entirely without foundation. The reason of this supposition seems to be, that in the countries where they grow naturally, they make the principal food of the poor people, who are generally troubled with these vermin. The wood of the sycamore is not subject to rot, and has therefore been used for making coffins in which embalmed bodies were put. Mr. Hasselquist affirms, that he saw in Egypt coffins made of this kind of wood, which had been preserved sound for 2000 years.

FIDD, in the sea language, an iron or wooden pin, to splice and fasten ropes together. It is made taperwise, and sharp at one end. The pin in the heel of the top-mast, which bears upon the chesse-trees, is likewise called a fidd.

FIELD, in heraldry, is the whole surface of the shield, or the continent, so called because it contains those achievements anciently acquired on the field of battle. It is the ground on which the colours, bearings, metal, furs, charges, &c. are represented. Among the modern heralds, field is less frequently used in blazoning than shield or escutcheon.

Field-book, in surveying, that in which the angles, stations, distances, &c. are set down. See Surveying.

Field-colours, in war, are small flags of about a foot and a half square, which are carried along with the quarter-masters general, for marking out the ground for the squadrons and battalions.

Field-fare. See Turdus.

Field-pieces, small cannons, from three to twelve pounders, carried along with an army in the field.

Field-staff, a weapon carried by the gunners, about the length of a halbert, with a spear at the end, having on each side ears screwed on, like the cock of a match-lock, where the gunners screw in lighted matches, when they are upon command; and then the field-staffs are said to be armed.

Field-works, in fortification, are those thrown up by an army in besieging a fortress, or by the besieged to defend the place. Such are the fortifications of camps, highways, &c.

FIERI FACIAS, a writ judicial, that lies at all times within the year and day for him who has recovered in an action of debt or damages, to the sheriff, to command him to levy the debt or damages of his goods against whom the recovery was had. Upon a fieri facias, the sheriff cannot deliver the defendant's goods to the plaintiff in satisfaction of his debt; nor ought he to deliver them to the defendant against whom execution is; but the goods are to be sold, and in strictness, the money is to be brought into court. Cro. Eliz. 504.

If the defendant dies after the execution awarded, and before it is served, yet it may be served upon his goods in the hands of his executor or administrator; for if the execution is awarded, the goods are bound, and the sheriff need not take notice of his death. 1 Mod. 188. And upon a fieri facias, the sheriff may take any thing but wearing clothes. Cumb. 356.

FIFE, or *Fiffario*, a shrill wind-instrument of the martial kind, consisting of a short narrow tube, with holes disposed along the side, for the regulation of its tones. It is not blown at the end, but at the side, like a German flute.

FIFTEENTH, an ancient tribute or tax laid upon cities, boroughs, &c. throughout all England, and so termed because it amounted to a fifteenth part of what each city or town had been valued at; or it was a fifteenth of every man's personal estate according to a reasonable valuation. In Doomsday-book, there are certain rates mentioned for levying this tribute yearly. The present property-tax seems a revival of the ancient system.

Fifteenth, in music, the appellation given to a certain stop in the organ. See Stop.

Fifteenth, an interval consisting of two octaves.

FIFTH, in music, a distance comprising four diatonic intervals, *i. e.* three tones and a half. The fifth is the second of the consonances in the order of their generation.

Fifth, *sharp*. The sharp fifth is an interval consisting of eight semitones.

FIG. See Ficus.

FIGURATE *numbers*, such as do or may represent some geometrical figure. in relation to which they are always considered; as triangular, pentagonal, pyramidal, &c. numbers.

Figurate numbers are distinguished into orders, according to their place in the scale of their generation, being all produced one from another, viz. by adding continually the terms of any one, the successive sums are the terms of the next order, beginning from the first order, which is that of equal units 1, 1, 1, 1, &c.; then the 2d order consists of the successive sums of those of the first order, forming the arithmetical progression 1, 2, 3, 4, &c.; those of the 3d order the successive sums of those of the 2d, and are the triangular numbers 1, 3, 6, 10, 15, &c.; those of the 4th order are the successive sums of those of the 3d, and are the pyramidal numbers 1, 4, 10, 20, 35, &c.; and so on, as below.

Order.	Name.	Number.				
1.	Equals,	1,	1,	1,	1,	1, &c.
2.	Arithmeticals,	1,	2,	3,	4,	5, &c.
3.	Triangulars,	1,	3,	6,	10,	15, &c.
4.	Pyramidals,	1,	4,	10,	20,	35, &c.
5.	2d Pyramidals,	1,	5,	15,	35,	70, &c.
6.	3d Pyramidals,	1,	6,	21,	56,	126, &c.
7.	4th Pyramidals,	1,	7,	28,	84,	210, &c.

The above are all considered as different sorts of triangular numbers, being formed from an arithmetical progression, whose common difference is 1. But if that common difference is 2, the successive sums will be the series of the square numbers; if it be 3, the series will be pentagonal numbers, or pentagons; if it be 4, the series will be hexagonal numbers, or hexagons, and so on. Thus:

Arithmecal.	1st Sums or polygons.	2d Sums, or 2d Polygons
1, 2, 3, 4,	Tri. 1, 3, 6, 10	1, 4, 10, 20
1, 3, 5, 7,	Sqrs. 1, 4, 9, 16	1, 5, 14, 30
1, 4, 7, 10,	Pent. 1, 5, 12, 22	1, 6, 18, 40
1, 5, 9, 13,	Hex. 1, 6, 15, 28	1, 7, 22, 50
&c.		

And the reason of the names triangles, squares, pentagons, hexagons, &c. is, that those numbers may be placed in the form of these regular figures or polygons.

FIGURE, in conic sections, according to Apollonius, is the rectangle made under the latus rectum and transversum in the hyperbola and ellipsis.

Figure of the diameter; the rectangle under any diameter, and its proper parameter, is, in the ellipsis and hyperbola, called the figure of that diameter.

Figure, in fortification, the plan of any fortified place, or the interior polygon, which, when the sides and angles are equal, is called a regular, and when unequal, an irregular figure.

Figure, in geometry: the superficies included between one or more lines, is denominated either rectilinear, curvilinear, or mixt, according as the extremities are bounded by right lines, curve lines, or both.

Figure, in grammar, a deviation from the natural rules of etymology, syntax, and prosody, either for brevity, elegance or harmony.

Figure, in logic, denotes a certain order and disposition of the middle term in any syllogism.

Figures are fourfold: 1. When the middle term is the subject of the major proposition, and the predicate of the minor, we have what is called the first figure. 2. When the middle term is the predicate of both the premises, the syllogism is said to be in the second figure. 3. If the middle term is the subject of the two premises, the syllogism is in the third figure; and lastly, by making it the predicate of the major, and subject of the minor, we obtain syllogisms in the fourth figure. Each of these figures has a determinate number of moods, including all the possible ways in which propositions differing in quantity or quality can be combined, according to any disposition of the middle term, in order to arrive at a just conclusion.

Figure, in painting and designing, denotes the lines and colours which form the representation of any animal,

but more particularly of a human personage. Thus a painting it said to be full of figures when there are abundance of representations of men; and a landscape is said to be without figures when there is nothing but trees, plants, mountains, &c. See PAINTING.

FIGURE, in rhetoric, is a manner of speaking different from the ordinary and plain mode, and more emphatical, expressing a passion, or containing a beauty. See RHETORIC.

FIGURED, in music, a term applied to that descendant, which, instead of moving note by note with the bass, consists of a free and florid melody. A bass, accompanied with numerical characters, denoting the harmony formed by the upper or superior parts of the composition, and directing the chords to be played by the organ, harpsichord, or piano-forte, is called a figured bass.

FIGURES: figures are not allowed to express numbers in indictments, but numbers must be expressed in words. Cro. Car. 109.

Roman figures are good in pleading, but otherwise of English figures. 2 Lev. 102.

FILACER, FILIZER, or FILAUR, an officer of the court of common-pleas, so called because he files those writs whereon he makes out process. There are fourteen of them in their several divisions and counties, and they make out all writs and process upon original writs, issuing out of chancery, as well in real, as in personal and mixed actions; and in actions merely personal, where the defendants are returned summoned, they make out pones and attachments, which being returned and executed, if the defendant appears not, they make forth a distringas, and so ad infinitum, or until he does appear; if he is returned nihil, then process of capias infinite, &c. They enter all appearances and special bails, upon any process made by them. They make the first scire facias upon special bail, writs of habeas corpus, distringas, nuper vicecomitem vel ballivum, and duces tecum, and all supersedeas upon special bail or otherwise; writs of habeas corpus cum causa, upon the sheriff's return, that the defendant is retained with other actions; writs of adjournment of a term, in case of pestilence, war, or public disturbance.

FILAGO, a genus of the polygamia necessaria order, in the syngenesia class of plants, and in the natural method ranking under the 49th order, compositæ. The receptacle is naked; there is no pappus; the calyx is imbricated; the female florets placed among the scales of the calyx. There are seven species, commonly known by the name of cudweed, natives of most parts of Europe, herbaceous, most of them annual.

FILAMENT. See BOTANY.

FILAMENTS, *vegetable*, form a substance of great use in the arts and manufactures; furnishing thread, cloth, cordage, &c. For these purposes the filamentous parts of the cannabis and linum, or hemp and flax, are employed among us. But different vegetables have been employed in different countries for the same uses. Putrefaction destroys the pulpy or fleshy matter, and leaves the tough filaments entire; by curiously macerating the leaf of a plant in water, we obtain the fine flexible fibres which constituted the basis of the ribs and minute veins, and which now form a skeleton of the leaf.

The sieur de Flacourt, in his History of Madagascar, relates, that different kinds of cloth are prepared in that island from the filaments of the bark of certain trees boiled in strong ley; that some of these cloths are very fine, and approach to the softness of silk, but in durability come short of cotton; that others are coarser and stronger, and last thrice as long as cotton; and that of these the sails and cordage of his vessel were made.

The same author informs us, that the stalks of nettles are used for the like purposes in France. And sir Hans Sloane relates, in one of his letters to Mr. Ray, that he has been informed by several, that muslin and calico, and most of the Indian linens, are occasionally made from nettles.

In some of the Swedish provinces, a strong kind of cloth is said to be prepared from hop-stalks; and in the Transactions of the Swedish academy for the year 1750, there is an account of an experiment made in consequence of that report. Of the stalks, gathered in autumn, about as many were taken, as equalled in bulk a quantity of flax that would have produced a pound after preparation. The stalks were put into water, and kept covered with it during the winter. In March they were taken out, dried in a stove, and dressed as flax. The prepared filaments weighed nearly a pound, and proved fine, soft, and white: they were spun and woven into six ells of fine strong cloth. The author, Mr. Shisler, observes, that hop-stalks take much longer time to rot than flax; and that if not fully rotted, the woody part will not separate, and the cloth will neither prove white nor fine.

Hemp, flax, and all other vegetable filaments, and thread or cloth prepared from them, differ remarkably from wool, hair, silk, and other animal productions, not only in the principles into which they are resoluble by fire, but likewise in some of their more interesting properties, particularly in their disposition to imbibe colouring matters; many liquors, which give a beautiful and durable dye to those of the animal, giving no stain at all to those of the vegetable kingdom.

Fishing-nets are usually boiled with oak-bark, or other such astringents, which render them more lasting. Those made of flax receive from this decoction a brownish colour, which, by the repeated alternations of water and air, is in a little time discharged, whilst the fine glossy brown communicated by the same means to silken nets, permanently resists both the air and water, and lasts as long as the animal filaments themselves. In like manner the stain of ink, or the black dye from solutions of iron, mixed with vegetable astringents, proves durable in silk and woollen; but from linen the astringent matter is extracted by washing, and only the yellow iron-mould remains.

Many other instances of this kind are known too well to the callico-printer, whose grand desideratum is to find means of making the fibres of cotton receive the same colours that wool does. See CALLICO-PRINTING.

FILARIA, a genus of insects of the order intestina; body round, filiform, equal, and quite smooth; mouth dilated, with a roundish concave lip. There are several species, some infesting the mammalia, other infesting birds, others infesting insects in their perfect state, and some infesting the larvæ of insects. The medinensis is the most remarkable species; it inhabits the Indies, and

is frequent in the morning dew, whence it enters the naked feet of the slaves, and creates the most troublesome itchings, accompanied with inflammation and fever. It must be cautiously drawn out by means of a piece of silk tied round its head, for if the animal should break, the remaining part grows with redoubled vigour, and is often fatal. It is frequently 12 feet long, and not larger than a horsehair.

FILBERT, or Filberd. See Corylus.

FILE, among mechanics, a tool used in metal, &c. in order to smooth, polish, or cut.

This instrument is of iron, or forged steel, cut in little furrows, with chisels, and a mallet, in a certain direction, and of a certain depth, according to the grain or touch required. After cutting the file, it must be tempered with a composition of chimney-soot, very hard and dry, diluted, and wrought up with urine, vinegar, and salt; the whole being reduced to the consistence of mustard. Tempering the files consists in rubbing them over with this composition, and covering them in loam; after which they are put into a charcoal fire, and taken out by the time they have acquired a cherry-colour, which is known by a small rod of the same steel put in along with them. Being taken out of the fire, they are thrown into cold spring-water, and when cold, they are cleaned with charcoal and a rag, and being clean and dry, are kept from rust by laying them up in wheat bran. Iron files require more heating than steel ones. Files are of different forms, sizes, cuts, and degrees of fineness, according to the different uses and occasions for which they are made. Those in common use are the square, flat, triangular, half-round, round, thin file, &c. each of which may be of different sizes, as well as different cuts.

The rough or coarse-toothed files are to take off the unevenness of the work which the hammer made in the forging; and the fine-toothed files are to take out of the work the deep cuts or file strokes of the rough files; the files succeed one another in this order, first the rubber, then the bastard-toothed file, next the fine-toothed file, and lastly the smooth file. Thus the files of different cuts succeed one another, till the work is as smooth as it can be filed; after which it may be made still smoother, by emery, tripoli, &c. In using all sorts of files, the rule is to lean heavy on the file in thrusting it forward, because the teeth of the files are made to cut forward; but in drawing the file back again for a second stroke, it is to be lightly lifted just above the work, as it does not cut in coming back.

There are several machines invented for cutting files, by which a blind man can cut a file with more exactness than can be done in the usual method with the keenest sight. These machines may be worked by water as readily as by hand, and are adapted to cut coarse or fine, large or small, files, or any number at a time. Mr. Nicholson, a few years since, obtained a patent for machinery for the manufacture of files; which consists, 1. Of a carriage in which the file is fixed and moved along, for the purpose of receiving the successive strokes of a cutter or chisel. 2. The anvil by which the file is supported beneath the part which receives the stroke. 3. The regulating gear by which the distance between stroke and stroke is determined and governed: and 4. The apparatus for giving the stroke or cut. The four several parts aforesaid are supported by a frame of solid workmanship, either of wood or metal, or both, according to the nature of the work to be performed.

The action of this machinery is thus described: 1. The file, being prepared as usual for cutting, must be fixed in the clip of the carriage, and the sliding block brought up and fixed, to steady the other extremity. 2. The nut of the screw being then opened, the carriage is slided to its place, so that the chisel may be situated over that part of the file which is to receive the first stroke. 3. The nut is then closed, and the small roller of the pressing lever is made to bear upon the face of the file. 4. The first mover being then put into action, raises and lets fall the apparatus for giving the stroke by which the file receives a cut. 5. Immediately afterwards, or during the same action, as the case may be, the regulating gear moves the carriage, and consequently the file, through a certain space. 6. This cut is then again given, and in this manner the file becomes cut throughout. The file is then taken out and cut on the other side; the bur is taken off, or not, as the artist judges fit, and the cross strokes are given over the surface as before. This machinery, by means of certain slight alterations, is adapted to the manufacture of all descriptions of files whether floats, rasps, or those of any figure and denomination.

File, in the art of war, a row of soldiers standing one behind another, which is the depth of the battalion, or squadron. The files of a battalion of foot are generally three deep, as are sometimes those of a squadron of horse. The files must be straight, and parallel one to another.

File, in law, is a record of the court; and the filing of a process of court, makes a record of it. Lill. 212.

FILIX, an order of the cryptogamia class of plants, comprehending the fern, horse-tail, adder's-tongue, maiden-hair, spleen-wort, polypody, &c.

FILUM, *in music* (Lat.), the name formerly given to the line drawn from the head of a note upwards, or downwards, and which is now called the tail.

FILLET, in heraldry, a kind of bordure, containing only a third or fourth part of the breadth of the common bordure. It is supposed to be withdrawn inwards, and is of a different colour from the field. It runs quite round, near the edge, as a lace over a cloak. It is also used for an ordinary drawn like a bar, from the sinister point of the chief, across the shield, in manner of a scarf; though it sometimes is also seen in the situation of a bend, fesse, cross, &c.

FILTER, or Filtre, in chemistry, a strainer commonly made of bibulous or filtring paper, in the form of a funnel, through which any fluid is passed, in order to separate the gross particles from it, and render it limpid.

FILTERING paper, is paper without size. To use it as such, the paper is shaped into the form of a cone, and placed in a funnel, in order to support it; otherwise it would break.

Filtering stones, basons, &c. are either natural or artificial for the purpose of purifying water. Natural filtres are found in rocks, mountains, beds of sand, gravel, &c. Artificial filtering-basons consist of equal parts of pipe-clay, and coarse sand. They should be three-quarters of an inch thick.

FILTRATION, is a finer species of sifting. It is sifting through the pores of paper, or flannel, or fine linen, or sand, or pounded glass, or porous stones, and the like; but it is used only for separating fluids from solids or particles, that may happen to be suspended in them, and not chemically combined with the fluids. Thus salt water cannot be deprived of its salt by filtration, but muddy water may be cleansed by it. No solid, even in the form of powder, will pass through filtering substances. If water or any other fluid containing sand, insects, &c. is placed in a bag or hollow vessel, made of any of those substances, the sand, &c. will remain upon the filtre, and the liquor will pass clear through it, and may be received in a vessel placed under it.

Mr. Peacock obtained, about twelve years since, a patent for a new species of filtration, by means of gravel of different sizes suitable to the several strata. The various sizes of the particles of gravel, as placed in layers, should be nearly in the quadruple ratio of their surfaces; that is, upon the first layer, a second is to be placed, the diameter of whose particles are not to be less than one-half of the first, and so on in this proportion. This arrangement of filtring particles will gradually fine the water by the grosser particles being quite intercepted in their partly ascending with the water. An advantage in these filtres is, that they may be readily cleansed by drawing out the body of the fluid, by which it will descend in the filtre, and carry with it all the foul and extraneous substances.

FIMBRIÆ, denotes appendages disposed by way of fringe round the border of any thing.

FIN, in natural history, a well-known part of fishes, consisting of a membrane supported by rays, or little bony or cartilaginous ossicles. The number, situation, and figure of fins, are different in different fishes. As to number, they are found from one to ten, or more; with respect to situation, they stand either on the back only, the belly only, or on both; and as to figure, they are either of a triangular, roundish, or oblong square form. Add to this, that in some they are very small; whereas, in others, they almost equal the whole body in length.

FINAL, *in music*, an old appellation given to the last sound of a verse in a chant; which, if complete, is on the key note; if incomplete, on some other note of the key.

FINAL Letters, among Hebrew grammarians, five letters so called, because they have a different figure at the end of words from what they have in any other situation.

FINALE (Ital.) a word signifying the last composition performed in any act of an opera, or part of a concert.

FINANCE, the œconomy of the public revenue and expenditure of nations. In former times, when the whole revenue drawn from the people by a few moderate and long-established taxes, was considered as the personal property of the sovereign, the purposes to which it was applied depended entirely on his discretion or that of his minister, as few princes were inclined in time of peace to reserve any part of their income as a provision for the additional expenses of war; the extraordinary charges incurred in times of hostility were defrayed by extraordinary contributions from the people, which ceased with the occasion of them. Few sovereigns possessed sufficient credit either with their own subjects or foreigners to contract debts, so that at the conclusion of a war there was no occasion for a greater expenditure than before its commencement, and the revenue drawn from the people reverted to its former state. It is the system of defraying extraordinary expenses by borrowing the money, for which an annual interest must be paid; and of suffering the debts thus incurred to accumulate, by which the sum to be annually paid is continually increasing, and the expenses of every war are rendered far greater than those which preceded it; that has swelled the revenue and expenditure of most of the nations of Europe to an enormous magnitude, and caused their systems of finance to become complicated and oppressive. In Great Britain, where the system of running in debt, or, as it is commonly termed, the funding system, has been carried to a greater height than in any other country, its natural attendants, enormous taxation and expenditure, have made equal progress; and it is probably owing chiefly to the publicity which is given to all matters of finance, so that every person with little trouble may know how all the money raised for the public service is expended, that the people have been induced to submit to taxes which both from their nature and amount would have appeared incredible to their forefathers.

The English system of finance rests on the produce of the various taxes which have been imposed at different periods, the aggregate amount of which, after deducting the expenses of collection, together with a few small articles which cannot properly be called taxes, forms the whole of the public income. This income is annually appropriated to the several branches of the national expenditure, and when in consequence of any extraordinary expenses it is known that the income of the current year will be insufficient to meet all the demands upon it, it is usual to borrow the sum necessary to make up the deficiency, either from individuals or public bodies, and to allow a fixed rate of interest on the money thus obtained, till the principal shall be repaid, or till the period originally agreed upon shall have expired. See Revenue, Loans, and National Debt.

The chancellor of the exchequer is, in Great Britain, the officer to whom the arrangement of the financial concerns of the country is chiefly intrusted. He causes accounts to be annually laid before parliament of the produce of the taxes, with estimates of the several branches of public expenditure for the ensuing year; and if the amount of the estimated expenditure exceeds the probable produce of the revenue, he adjusts the extent and conditions of the loan with such persons as are willing to advance the same, and proposes to parliament the new taxes which become necessary for paying the interest on the money thus borrowed. On the foundation of the accounts and estimates submitted to parliament, particular sums are voted for the several branches of the expenditure; and when the ways and means of raising the whole sum wanted have been determined, an act is passed appropriating the specific sums to the various articles forming the supplies which have been granted. In order to provide against any unforeseen expenses, it is

usual to grant also a certain sum appropriated to any particular purpose, to be applied to any branch of the expenditure in which there may be occasion for it; this is called a vote of credit, and has increased in amount with the progress of the supplies; in the American war it was 1,000,000*l.* per annum, of late it has generally been 2,500,000*l.* Soon after the commencement of each session, an account is laid before the house of commons, showing how the moneys given for the service of the preceding year have been disposed of, and what part thereof remains unpaid. If the ways and means have fallen short of the sum they were expected to produce, the deficiency is made good as an article among the next year's supplies.

All the financial accounts of Great Britain are made up annually, and do not vary materially except in the amount of the several articles. A general view of the ordinary revenues and extraordinary resources constituting the public income for the year ending the 5th January, 1805, and of the different branches of the public expenditure for the same period, will furnish a distinct and comprehensive view of the subject, for the detail of which see CUSTOMS, EXCISE, STAMP-DUTIES, LAND-TAX, &c.

PUBLIC INCOME.

ORDINARY REVENUES.			
Customs - - - - - - - - - - - - - -	*l.* 9,060,297	8	2½
Excise (including Malt, &c. annual) - - - - - - - - -	20,990,469	13	1
Stamps - - - - - - - - - - - - - -	3,564,894	10	6½
Land and Assessed Taxes - - - - - - - - - - -	6,042,485	3	3½
Post Office - - - - - - - - - - - - - -	1,107,358	9	1½
Shilling in the Pound on Pensions and Salaries - - - - - -	52,997	19	7¼
Sixpence in the Pound on ditto - - - - - - - - - -	61,278	6	4
Hackney Coaches - - - - - - - - - - - -	26,656	11	3¾
Hawkers and Pedlars - - - - - - - - - - - -	7,014	3	7
Small branches of the Hereditary Revenue, viz. Alienation Fines, Post Fines, Seizures, Compositions, Proffers, and Crown Lands - - - -	131,980	12	7
EXTRAORDINARY RESOURCES.			
Property Tax - - - - - - - - - - - - -	3,484,351	10	5
Arrears of Income Duty - - - - - - - - - - -	81,048	6	9¼
Lottery, Net Profit - - - - - - - - - - - -	413,645	7	2
Voluntary Contributions - - - - - - - - - - -	590	17	9
Arrears of Taxes, collected under the Aid and Contribution Act - -	1,890	13	2¼
Moneys paid on account of the Interest of Loans raised for the service of Ireland	1,275,178	17	1
On account of the Commissioners for issuing Exchequer Bills for the Island of Grenada, &c. - - - - - - - - - - - - -	201,000	0	0
Interest on Stock, transferred by Instalments, for the Redemption of Land Tax	4,500	0	0
Fees of regulated Exchequer Offices - - - - - - - - -	36,664	7	0
Imprest Monry repaid by sundry Public Accountants - - - - -	21,031	5	2¼
Other Moneys paid to the Public - - - - - - - -	13,230	0	2
Total, independent of Loans - - - - - t -	46,578,564	2	4¾
Loans, in part of 14,500,000*l.* - - - - - - -	13,209,351	13	9
Total - -	*l.* 59,787,915	16	1¾

PUBLIC EXPENDITURE.

	l.	*s.*	*d.*	*l.*	*s.*	*d.*
Interest on the permanent Funded Debt - -	18,925,797	6	3¾	26,044,785	16	11
Charges of Management - - - - -	267,786	19	7¼			
Sums applicable to the reduction of the Debt	6,851,201	11	0			
Interest on Exchequer Bills - - - - - - - - - -				624,859	18	10
The Civil List - - - - - - - - - - - - -				928,000	0	0
Other charges on the Consolidated Fund, viz.						
Allowances to the Royal Family, Pensions, &c.	284,866	13	4	409,811	10	9
Salaries and Allowances - - - - -	23,441	19	0			
Courts of Justice - - - - - -	57,319	2	0			
The Mint - - - - - - - - -	20,727	2	9			
Bounties - - - - - - - - -	23,456	13	8			
The Civil Government of Scotland - - - - - - - -				79,705	4	1¾
Other payments in anticipation of the Exchequer Receipt, viz.						
Bounties for Fisheries, Manufactures, Corn, &c.	336,524	0	11	727,582	3	11
Pensions on the Hereditary Revenue - -	27,700	0	0			
Militia and Deserters' Warrants, &c. -	286,668	10	6			
Purchase of Legal Quays - - - - -	76,689	12	6			

The Navy	7,345,821	4	9	11,759,351	5	5
Victualling Department	3,279,501	8	4			
Sick and Wounded ditto	277,000	0	0			
Transport ditto	857,028	12	4			
The Ordnance				3,550,141	1	11
The Army. Regulars, Fencibles, Militia, &c.	9,500,000	0	0	15,744,694	15	3
Barracks	1,786,048	0	0			
Staff Officers, and Officers of Garrisons	289,027	0	0			
Half-Pay	228,000	0	0			
Widows' Pensions	22,500	0	0			
Chelsea Hospital	207,963	0	0			
Exchequer Fees	80,353	0	0			
Pay of Public Offices	70,000	0	0			
Extraordinary Services	3,560,803	15	3			
Remittances to Ireland, viz.						
Out of Loan, 1804	3,693,500	0	0	3,733,291	13	4
Out of Lotteries, 1804	39,791	13	4			
Miscellaneous Services,						
At Home	1,628,555	0	3¾	1,882,074	14	8¾
Abroad	253,519	14	5			
				65,484,298	5	2½
Deduct Loan for Ireland				3,733,291	13	4
Total				L. 61,751,006	11	10½

FINDING: any person finding any thing, has a special property therein, but he is answerable to the person in whom is the general property, but has a right against every person but the loser. The finder is not answerable for a mere nonfeasance or neglect: yet if he makes gain of, or abuses, or spoils the things he finds, he shall be answerable. If bank-bills, tickets, &c. stolen or lost, are paid to or delivered to another, without consideration, an action lies against any one in whose hands they are found; and the law seems to be the same, though a consideration was given, if the party had previous notice of their being lost or stolen. Str. 505.

But the property of goods found or stolen, may be changed by sale for a valuable consideration, and without notice, in a market overt; and the party purchasing them obtains a title to them, against the original owner.

FINES, a mode of transferring property. By the ancient common law, a charter of feoffment was the only written instrument by which lands were conveyed; but the inconvenience sometimes arising from the loss of the charter, or the difficulty of proving it from a lapse of years, induced men to look out for some more secure and lasting assurance. For this purpose fines were adopted, that is, a fictitious process; a suit is instituted concerning the lands intended to be conveyed; and after the writ is issued and the parties appear in court, the suit is compounded with the consent of the judges, whereby the lands in question are acknowledged to be the right of one of the contending parties. This agreement is inrolled among the records of the court, and being substituted in the place of the sentence which would have been given had the action continued, is of equal force with the judgment of a court, puts an end not only to that suit but to all others respecting the same matter; a writ is then issued to the sheriff of the county in which the lands lie, in the same form as if judgment had been obtained, commanding him to deliver possession to the person who thus acquires the land, which renders the ceremony of livery of seisin unnecessary. We are indebted to the civilians for the first idea of this method of conveyance, by whom it was called *transactio*, and was introduced by the French into their law. A fine consists of five parts: 1st. The original writ; 2nd. The licencia concordandi; 3rd. The concord; 4. The note; 5. The foot. A fine can be levied on any writ which in any sort concerns lands, but the writ chiefly in use, is the writ of covenant. When the sheriff of the county where the lands lie is a party to the fine, the writ must be directed to the coroner; the licentia concordandi is the permission from the court to accommodate the suit. The concord comes in lieu of the sentence which would have been given had the action continued. The note is only the abstract of the writ of covenant, and the concord, naming the parties, the lands, and the agreement; and the foot chirograph or indenture includes the whole matter. Sir Edward Coke says, a fine is said to be levied when the writ of covenant is returned, and the concord duly entered. Fines are divided into executed and executory; and subdivided into, 1st. *Fines sur cognizance de droit comme ceo;* 2. *sur cognizance de droit tantum;* 3. *sur concessit;* and 4. *sur done grant et render.* A fine sur cognizance de droit comme ceo, &c. is the best and surest kind of fine, for thereby the deforciant in order to keep his covenant with the plantiff, of conveying to him the lands in question, and at the same time to avoid the formality of an actual feoffment and livery, acknowledges in court a former feoffment to have been made by him to the plaintiff, so that this assurance is rather a confession of a former conveyance, than a conveyance now originally made. A fine sur cognizance de droit tantum, is merely the acknowledgement of the right without the circumstance of a preceding gift from the cognizor, and

is commonly used to pass a reversionary interest which is in the cognizor. A fine sur concessit, is where the cognizor, though he acknowledges no precedent right, yet grants to the cognizee an estate de novo usually for life or years by way of supposed composition; and this may be done reserving a rent or the like, for it operates as a new grant. A fine sur done grant et render, is a double fine, comprehending the fine sur cognizance de droit comme ceo, and the fine sur concessit, and may be used to create particular limitations of estate; whereas the first conveys nothing but an absolute estate, and is the most used on that account: this is called a fine executed, and the others are but executory.

Fines were formerly levied in all the courts; but by Magna Charta they were usually thenceforth levied in the common pleas, and before two justices of that court; and the lord chief justice of the common pleas may alone take the acknowledgment of a fine out of court: but if he is a party to the writ, he cannot *quia judex in propria causa.* This rule extends to all our judges and commissioners. They are also taken by commissioners in the country, empowered by dedimus potestatem, who may be punished for abuses, and the fine taken before them set aside: and it may be levied of any things whereof a *precipe quod reddat* or *precipe quod faciat* lies, or a *precipe quod permittat* or *precipe quod teneat* may be brought. The force and effect of a fine depend principally on the common law, and the two statutes 4 Hen. VII. c. 24, and 32 Henry VIII. c. 36. The ancient common law as set forth in 18 Edward I. says, "the fine is so high a bar, and of so great force, and of a nature so powerful in itself, that it precludes not only those who are parties and privies to the fine, and their heirs, but all other persons in the world who are of full age, out of prison, of sound memory, and within the seas, the day of the fine levied, unless they put in their claim within a year and a day." But by a statute made in the reign of Edward I. persons were allowed to claim and falsify a fine at any indefinite time; but this giving rise to much contention and insecurity, a statute 6 Henry VII. wisely steered between the rigour of the common law and the latitude allowed by the former act, and limited the right of claim to five years, except femme-coverts, infants, prisoners, persons beyond the seas, or lunatics, who have five years after the death of their husbands, their attaining full age, recovering their liberty, or being restored to their right mind. The persons bound by a fine, are parties, privies, and strangers: the parties are the cognizors and cognizees, and all persons who may lawfully grant by deed may levy a fine, and this is almost the only act that a femme covert is allowed to do (when she is privately examined as to her voluntary consent), and is therefore the most usual and safe method whereby she can join in the sale, settlement, or incumbrance of any estate. Privies to a fine are such as are anywise related to the parties who levy the fine, and claim under them by any right of blood or other right of representation. Strangers to a fine are all other persons in the world except only parties and privies, who are also bound by a fine unless they prefer their claims within the space of five years. Persons who have not a present but future interest only have also five years allowed them to claim in from the time that right accrues; thus this conveyance not only binds the parties themselves and their heirs, but also all mankind whether concerned or no, if they fail to put in their claims within the time allowed by law.

Fines *for offences.* Originally all punishments were corporal; but after the use of money, when the profits of the courts arose from the money paid out of the civil causes, and the fines and confiscations in criminal ones, the commutation of punishments was allowed of; and the corporal punishment which was only in terrorem, changed into the pecuniary, whereby they found their own advantage. This begat the distinction between the greater and the less offences; for in the crimina majora there was at least a fine to the king, which was levied by a capiatur; but upon the less offences there was only an amercement, which was affeered, and for which a distringas, or action of debt only lay. 2 Bac. Abr. 502.

By the Bill of Rights 1 W. st. 2. c. 2. excessive fines ought not to be imposed; and all grants and promises of fines and forfeitures of particular persons, before conviction, are declared to be illegal and void. 4 Black. 379.

All courts of record may fine and imprison an offender, if the nature of the offence is such as deserves such punishment. 8 Co. 39. But no court, unless of record, can fine or imprison. 11 Co. 43. And all courts of law that have power given them to fine and imprison, are thereby made courts of record. 1 Salk. 200.

The sheriff in his torn, may impose a fine on all such as are guilty of any contempt in the face of the court; and may also impose what reasonable fine he shall think fitting, upon a suitor refusing to be sworn, or upon a bailiff refusing to make a panel, &c. or upon a tithingman neglecting to make his presentment, or upon one of the jury refusing to present the articles wherewith they are charged, or upon a person duly chosen constable refusing to be sworn. 2 Inst. 142.

Also the steward of a court-leet may by recognizance bind any person to the peace who shall make an affray in his presence, sitting the court; or may commit him to ward, either for want of sureties, or by way of punishment, without demanding any sureties of him; in which case he may afterwards impose a fine according to his discretion. F. N. B. 82.

Also the sheriff in his torn, and the steward of a court-leet, have a discretionary power either to award a fine or amercement for contempt of the court, for a suitor's refusing to be sworn, &c.; and the steward of a court-leet may either amerce or fine an offender, upon an indictment for an offence not capital, within his jurisdiction, without any farther proceeding or trial, especially if the crime was any way enormous, as an affray accompanied with wounding. Kitchin, 43, 51.

Some courts cannot fine or imprison, but amerce, as the county, hundred courts, &c. 11 Co. 43.

But some courts can neither fine, imprison, nor amerce; as ecclesiastical courts held before the ordinary, archdeacon, &c. or their commissaries, and such who proceed according to the canon or civil law. 11 Co. 44.

A fine may be mitigated the same term it was set, being under the power of the court during that time, but not afterwards. L. Raym. 376. And fines assessed in court by judgment upon an information, cannot be after-

wards mitigated. Cro. Car. 251. If a fine certain is imposed by statute on any conviction, the court cannot mitigate it; but if the party come in before conviction, and submit to the court, they may assess a less fine; for he is not convicted, and perhaps never might. The court of exchequer may mitigate a fine certain, because it is a court of equity, and they have a privy seal for it. 3 Salk. 33.

FINERS of gold and silver, are those who separate these metals from coarser ores.

FINERY, in the iron-works, one of the forges at which the iron is hammered and fashioned into what they call a bloom, or square bar.

FINGER, *in music*, a word metaphorically applied to ability in execution in general, but especially on keyed instruments; as when we say, such a master possesses an expressive or an elegant finger; that lady displays a rapid or a delicate finger.

Finger-board, that thin, black covering of wood laid over the neck of a violin, violoncello, &c. and on which, in performance, the strings are pressed by the fingers of the left hand, while the right manages the bow.

Fingering, disposing of the fingers in a convenient, natural, and apt manner in the performance on any instrument, but more especially the organ and piano-forte. Good fingering is one of the first things to which a judicious master attends. It is, indeed, to this that the pupil must look as the means for acquiring a facile and graceful execution, and the power of giving passages with articulation, accent, and expression. Easy passages may be rendered difficult, and difficult ones impracticable, by bad fingering; and though there are many arrangements of notes which admit of various fingering, still, even in these, there is always one best way of disposing of the hand, either with regard to the notes themselves, or those which precede or follow them. But there are an infinite number of possible dispositions of notes, which can only be fingered in one particular way; and every attempt at any other, is but endangering the establishment of some awkwardness, which the practitioner will have to unlearn before he can hope to attain the true fingering. Hence it is obvious, that no qualification requisite to good performance is of more importance to the learner than that of just fingering; and that whatever talents and assiduity may be able to achieve independent of instruction, in this great particular the directions of a skilful master are indispensable.

FINTO, in music (Ital.), a feint, a term applied to the preparation for a cadence which is not executed; when the performer having done every thing that is requisite to a full close, instead of falling on the final, passes to some other note, or introduces a pause.

FIR-tree. See Abies.

FIRE. See Caloric.

Fire, *wild*, a kind of artificial or factitious fire, which burns even under water. It is composed of sulphur, pitch, nitre, and various other combustible materials; and is very hard to extinguish. Chemistry, however, has supplied a still more destructive kind of wild-fire, in the union of nitrous acid with oil of turpentine. These two liquids separately are perfectly cold; but when suddenly mixed, produce a flame not easily extinguished. This, with great appearance of reason, is supposed to be the wild-fire of the ancients, who, inclosing the two liquids in a glass ball which had a partition to keep them asunder, threw the ball into some ship of the enemy's; and the globe being thus broken, the liquids united, and set the vessel in flames. The French call it Greek fire, or feu Gregois, because first used by the Greeks, about the year 660; as is observed by the jesuit Petavius, on the authority of Nicetas, Theophanes, Cedrenus, &c.

The inventor, according to the same jesuit, was an engineer of Heliopolis in Syria, named Callinicus, who first applied it in the sea-fight commanded by Constantine Pogonates against the Saracens, near Cyzicus, in the Hellespont; and with such effect, that he burnt the whole fleet in which were 30,000 men. But others will have it of a much older date; and hold Marcus Gracchus the inventor: which opinion is supported by several passages both in the Greek and Roman writers, which show it to have been anciently used by both these nations in their wars.

F. Daniel gives us a good description of the Greek fire in his account of the siege of Damietta under St. Louis. Every body, says that author, was astonished with the Greek fire, which the Turks then prepared, and the secret whereof is now lost. They threw it out of a kind of mortar; and sometimes shot it with an odd sort of cross-bow, which was strongly bent by means of a handle or winch, of much greater force than the mere arm. That thrown with the mortar sometimes appeared in the air of the size of a tun, with a long tail, and a noise like that of thunder. The French by degrees got the secret of extinguishing it, in which they succeeded several times.

Fire-place. Our ancestors, equally careless of fuel and patient of heat and of cold, basked before a large pile of burning wood with a screen at their backs; and in attempting to substitute a coal-fire, it was at first forgotten that bacon, &c. &c. was not to be hung in the chimney. Economical fire-places should be constructed on the following principles: 1. To place the grate as near the floor as may be. 2. To bring it as forward as may be, consistently with the proper situation of the throat of the chimney, which ought to be directly over the fire, and not larger than is sufficient to give free passage at all times to the smoke. 3. The mantle-piece should be as low as it can be without suffering from the heat, or obstructing the proper radiation of it into the room, from the fuel and flame. By these means, the feet and legs are easily warmed, and the face not so much incommoded; while a much greater volume of heated air is retained in a room of equal size than by high grates and large openings. Since it has been found that chimneys may be cleansed with long flexible brushes, why should they not be built of smaller diameter, circular, and smoothly plaistered within?

Fire, *machine for preserving from.* This machine consists of a pole, a rope, and a basket. The pole is of fir, or a common scaffold pole, of any convenient length from 36 to 40 feet; the diameter at bottom, or the greatest end, about five inches; and at the top or smallest end about three inches. At three feet from the top is a mortise through the pole, and a pulley fixed to it of nearly

the same diameter with the pole in that part. The rope is about three quarters of an inch diameter, and twice the length of the pole; with a spring hook at one end, to pass through the ring in the handle of the basket when used: it is put through the mortise over the pulley, and then drawn tight on each side near the bottom of the pole, and made fast there till wanted. The basket should be of strong wicker-work, three feet and a half long, two feet and a half wide, rounded off at the corners, and four feet deep, rounding every way at the bottom. To the top of the basket is fixed a strong iron curve or handle, with an eye or ring in the middle; and to one side of the basket, near the top, is fixed a small cord, or guide-rope, of about the length of the pole. When the pole is raised, and set against a house over the window from which any persons are to escape, the manner of using it is so plain and obvious, that it need not be described. The most convenient distance from the house for the foot of the pole to stand, where practicable, is about twelve or fourteen feet. If two strong iron straps, about three feet long, rivetted to a cross bar, and spreading about fourteen inches at the foot, were fixed at the bottom of the pole, this would prevent its turning round or slipping on the pavement. And if a strong iron hoop, or ferule, rivetted (or welded) to a semicircular piece of iron spreading about twelve inches, and pointed at the ends, was fixed on at the top of the pole, it would prevent its sliding against the wall.

When these two last-mentioned irons are fixed on, they give the pole all the steadiness of a ladder; and because it is not easy, except to persons who have been used to it, to raise and set upright a pole of forty feet or more in length, it will be convenient to have two small poles or spars of about two inches diameter, fixed to the sides of the great pole at about two or three feet above the middle of it, by iron eyes rivetted to two plates, so as to turn every way; the lower end of these spars to reach within a foot of the bottom of the great pole, and to have ferules and short spikes to prevent sliding on the pavement, when used occasionally to support the great pole like a tripod. There should be two strong ash-trundles let through the pole, one at four feet and one at five feet from the bottom, to stand out about eight inches on each side, and to serve as handles, or to twist the rope round in lowering a very heavy weight. If a block and pulley were fixed at about the middle of the rope, above the other pulley, and the other part of the rope made to run double, it would diminish any weight in the basket nearly one-half, and be very useful in drawing any person up, to the assistance of those in the chambers, or for removing any effects out of a chamber, which it might be dangerous to attempt by the stairs.

It has been proved, by repeated trials, that such a pole as we have been speaking of can be raised from the ground, and two or three persons taken out of the upper windows of a house, and set down safely in the street in the space of 35 seconds, or a little more than half a minute. Sick and infirm persons, women, children, and many others, who cannot make use of a ladder, may be safely and easily brought down from any of the windows of a house on fire by this machine, and by putting a short pole through the handles of the basket, may be removed to any distance without being taken out of the basket. The pole must always have the rope ready fixed to it, and may be conveniently laid up upon two or three iron hooks under any shade or gateway, and the basket should be kept at the watch-house. When the pole is laid up, the two spars should always be turned towards the head of it. The basket should be made of peeled rods, and the pole and spars painted of a light stone-colour, to render it more visible when used in the night.

Fire, *machines for extinguishing*. In the year 1734, the states of Sweden offered a premium of 20,000 crowns for the best method of stopping the progress of accidental fires; when one Mr. Fuches, a German physician, made a preparation for that end, and the experiment was tried on a house built on purpose, of dry fir, at Legard-island. In the building were placed several tubs of tar and pitch, and a great quantity of chips, all which were set on fire, flames issuing through the top of the house, windows, &c. when he threw in one of the barrels containing the preparation, which immediately quenched the flames; a second barrel entirely cleared the smoke away; and the whole was executed to the astonishment of the spectators, and to the no small satisfaction of the inventor, who was about to return home, when unexpectedly the flames broke out again, supposed to be occasioned by a small quantity of combustible matter being introduced and set on fire secretly by some malicious person. Upon this the wrongheaded mob fell upon Mr. Fuches, and beat him most unmercifully, so that he narrowly escaped with his life. He soon after left the country, and never could be prevailed on to return. Another experiment of this kind was tried in 1761 in Holland, but failed through the perverseness of the populace.

Attempts of a similar nature have met with a better reception in England. Of these the most successful was that of Mr. Godfrey, whose contrivance is thus described by Mr. Ambrose Godfrey, grandson to the inventor. "The material to be employed consists of a small portion of gunpowder closely confined; which, when animated by fire, acts by its elastic force upon a proper medium, and not only divides it into the minutest atoms, but disperses it also in every direction, so as immediately to extinguish any fire within a certain distance. This medium is a liquor strongly impregnated with a preparation of anticombustible principles, which by their action upon burning materials extinguish the flames, and reduce them in general to the state of a black coal; and, by its opposite nature to fire, hinders the remaining sparks, notwithstanding the admission of the air, from kindling the flames afresh. By this means, the great point is obtained, in giving sufficient time for totally extinguishing any remains of fire." From this account, however, nothing can be made out; and the quackery of concealment, in a matter that so nearly concerns the welfare of the human race, can only be accounted for on the score of its insufficiency, or the impossibility of making it generally useful.

The mode of employing these machines, was that of throwing them into the different rooms of the house in which the flames began to appear. Used in this way, if the invention really possessed the merit ascribed to it, it evidently would have been of great use in extin-

guishing fires on shipboard; and would probably have been considered as a no less necessary part of a ship's lading than her stores or ammunition.

Fire *in chimneys, method of extinguishing.* It is well known, that the inner parts of chimneys easily take fire; the soot that kindles therein emits a greater flame, according as the tunnel is more elevated, because the current of air feeds the fire. If this current could therefore be suppressed, the fire would soon be extinguished. In order to this, some discharge a pistol into the chimney, which produces no effect. Water thrown into the chimney at top is equally useless, because it comes down through the middle of the tunnel, and not along the sides. It would be more advisable to stop, with a wet blanket, the upper orifice of the tunnel; but the surest and readiest method is, to apply the blanket either to the throat of the chimney, or over the whole front of the fire-place. If there happens to be a chimney-board or a register, nothing can be so effectual as to apply them immediately; and having by that means stoppd the draught of air from below, the burning soot will be put out as readily and as completely as a candle is put out by an extinguisher, which acts exactly upon the same principle.

Fire, *securing buildings against.* Dr. Hales proposes to check the progress of fires by covering the floors of the adjoining rooms with earth. The proposal is founded on an experiment which he made with a fir-board half an inch thick, part of which he covered with an inch depth of damp garden-mold, and then lighted a fire on the surface of the mold; though the fire was kept up by blowing, it was two hours before the board was burnt through, and the earth prevented it from flaming. The thicker the earth is laid on the floors, the better: however, Dr. Hales apprehends that the depth of an inch will generally be sufficient: and he recommends to lay a deeper covering on the stairs, because the fire commonly ascends by them with the greatest velocity.

Mr. David Hartley made several trials in the years 1775 and 1776, in order to evince the efficacy of a method which he had invented for restraining the spread of fire in buildings. For this purpose, thin iron plates were well nailed to the tops of the joists, &c. the edges of the sides and ends being lapped over, folded together, and hammered close. Partitions, stairs, and floors, may be defended in the same manner; and plates applied to one side have been found sufficient. The plates are so thin as not to prevent the floor from being nailed on the joists, in the same manner as if this preventive was not used; they are kept from rust by being painted or varnished with oil and turpentine. The expense of this addition, when extending through a whole building, is reckoned at about five per cent. Mr. Hartley had a patent for this invention, and parliament voted a sum of money towards defraying the expense of his numerous experiments. The same preservative may also be applied to ships, furniture, &c. Mr. Hartley's patent has long since expired.

Earl Stanhope has also discovered and published a very simple and effectual method of securing every kind of building against fire. This method he has divided into three parts, viz. under-flooring, extra-lathing, and inter-securing. The method of under-flooring is either single or double. In single under-flooring, a common strong lath of oak or fir, about one fourth of an inch thick, should be nailed against each side of every joist, and of every main timber, supporting the floor which is to be secured. Other similar laths are then to be nailed along the whole length of the joists, with their ends butting against each other. The top of each of these laths or fillets ought to be at 1½ inch below the top of the joists or timbers against which they are nailed; and they will thus form a sort of small ledge on each side of all the joists. These fillets are to be well bedded in a rough plaister hereafter mentioned, when they are nailed on, so that there may be no interval between them and the joists; and the same plaister ought to be spread with a trowel upon the tops of all the fillets, and along the sides of that part of the joists which is between the top of the fillets and the upper edge of the joists. In order to fill up the intervals between the joists that support the floor, short pieces of common laths, whose length is equal to the width of these intervals, should be laid in the contrary direction to the joists, and close together in a row, so as to touch one another; their ends must rest upon the fillets, and they ought to be well bedded in the rough plaister, but are not to be fastened with nails. They must then be covered with one thick coat of the rough plaister, which is to be spread over them to the level of the tops of the joists; and in a day or two this plaister should be trowelled over close to the sides of the joists, without covering the tops of the joists with it.

In the method of double-flooring, the fillets and short pieces of laths are applied in the manner already described; but the coat of rough plaister ought to be little more than half as thick as that in the former method. Whilst this rough plaister is laid on, some more of the short pieces of laths above-mentioned must be laid in the intervals between the joists upon the first coat, and be dipped deep in it. They should be laid as close as possible to each other, and in the same direction with the first layer of short laths. Over this second layer of short laths there must be spread another coat of rough plaister, which should be trowelled level with the tops of the joists without rising above them. The rough plaister may be made of coarse lime and hair; or, instead of hair, hay chopped to about three inches in length may be substituted with advantage. One measure of common rough sand, two measures of slaked lime, and three measures of chopped hay, will form in general a very good proportion, when sufficiently beaten up together in the manner of common mortar. The hay should be put in after the two other ingredients are well beaten up together with water. This plaister should be made stiff; and when the flooring boards are required to be laid down very soon, a fourth or fifth part of quicklime in powder, formed by dropping a small quantity of water on the limestone a little while before it is used, and well mixed with this rough plaister, will cause it to dry very fast. If any cracks appear in the rough plaister-work near the joists when it is thoroughly dry, they ought to be closed by washing them over with a brush wet with mortar-wash; this wash may be prepared by putting two measures of quicklime and one of common

sand in a pail, and stirring the mixture with water till the water becomes of the consistence of a thick jelly.

Before the flooring-boards are laid, a small quantity of very dry common sand should be strewed over the plaister-work, and struck smooth with a hollow rule, moved in the direction of the joists, so that it may lie rounding between each pair of joists. The plaister-work and sand should be perfectly dry before the boards are laid, for fear of the dry rot. The method of under-flooring may be successfully applied to a wooden stair-case; but no sand is to be laid upon the rough plaister-work. The method of extra-lathing may be applied to ceiling joists, to sloping roofs, and to wooden partitions.

The third method, which is that of inter-securing, is very similar to that of under-flooring; but no sand is afterwards to be laid upon it. Inter-securing is applicable to the same parts of a building as the method of extra-lathing, but it is seldom necessary.

The author of this invention made several experiments, in order to demonstrate the efficacy of these methods. In most houses it is only necessary to secure the floors; and the extra expense of under-flooring, including all materials, is only about nine pence per square yard, and with the use of quicklime a little more. The extra expense of extra-lathing is no more than six pence per square yard for the timber side-walls and partitions; but for the ceiling about nine pence per square yard. But in most houses no extra-lathing is necessary.

Fire-flies, a species of flies in Guiana, of which there are two species. The largest is more than an inch in length, having a very large head connected with the body by a joint of a particular structure, with which sometimes it makes a loud knock, particularly when laid on its back. The fly has two feelers or horns, two wings, and six legs. Under its belly is a circular patch, which, in the dark, shines like a candle; and on each side of the head near the eyes is a prominent, globular, luminous body, in size about one-third larger than a mustard-seed. Each of these bodies is like a living star, emitting a bright, and not small, light; since two or three of these animals, put into a glass vessel, afford a light sufficient to read without difficulty, if placed close to the book. When the fly is dead, these bodies will still afford considerable light, though it is less vivid than before; and if bruised, and rubbed over the hands or face, they become luminous in the dark, like a board smeared over with English phosphorus. They are of a reddish-brown or chesnut colour; and live in rotten trees in the day, but are always abroad in the night. The other kind is not more than half as large as the former: their light proceeds from under their wings, and is seen only when they are elevated, like sparks of fire appearing or disappearing at every second. Of these the air is full in the night, though they are never seen in the day. They are common not only in the southern, but in the northern parts of America during summer.

Fire-ball, in the art of war, a composition of meal-powder, sulphur, saltpetre, pitch, &c. about the bigness of a hand-grenade, coated over with flax, and primed with a slow composition of a fuse. This is to be thrown into the enemy's works in the night time, to discover where they are: or to fire houses, galleries, or blinds of the besiegers; but they are then armed with spikes or hooks of iron, that they may not roll off, but stick or hang where they are designed to have effect.

Fire-bote, is fuel or firing for necessary use, allowed to tenants, out of the lands granted to them.

Fire-irons. These are too well known to need description: they are, however, mentioned, to notice a patent taken out by Mr. Bentham, for the improvement of them, by making all the parts that admit of it tubular instead of solid.

Fire-pots, in the military art, small earthen pots, into which is put a charged grenade, and over that powder enough till the grenade is covered; then the pot is covered with a piece of parchment, and two pieces of match across lighted: this pot being thrown by a handle of match, where it is designed, it breaks and fires the powder, and burns all that is near it, and likewise fires the powder in the grenade, which ought to have no fuse, that its operations may be the quicker.

FIRES and Firecocks. By 14 G. III. c. 78, church-wardens in London, and within the bills of mortality, are to fix firecocks, &c. at proper distances in streets and keep a large engine and hand-engine for extinguishing fire, under the penalty of ten pounds. And to prevent fires, workmen in the city of London, &c. must erect party-walls between buildings, or brick or stone of a certain thickness, &c. under penalties therein mentioned.

On the breaking out of any fire, all the constables and beadles shall repair to the place with their staves, and be assisting in putting it out, and causing people to work. No action lies against a person in whose house or chamber a fire accidentally begins.

Fire-ships, in the navy, are vessels charged with combustible materials or artificial fireworks; which having the wind of an enemy's ship, grapple her, and set her on fire.

Anderson, in his History of Commerce, vol. 1, p. 432, ascribes the invention to the English, in this instance, viz. some vessels being filled with combustible matter, and sent among the Spanish ships composing the Invincible Armada, in 1588; and hence arose, it is said, the terrible invention of fire-ships.

But Livy informs us, that the Rhodians had invented a kind of fire-ships, which were used in junction with the Roman fleet in their engagement with the Syrians, in the year 190 before Christ: cauldrons of combustible and burning materials were hung out at their prows, so that none of the enemy's ships durst approach them; for these fell on the enemies' galleys, struck their beaks into them, and at the same time set them on fire.

Firelocks, so called from their producing fire of themselves, by the action of the flint and steel; the arms carried by a foot-soldier. They were formerly three feet eight inches in the barrel, and weighed fourteen pounds; at present the length of the barrel is from three feet three inches to three feet six inches, and the weight of the piece only twelve pounds. They carry a leaden bullet of which 29 make 2lb. its diameter is .550 of an inch, and that of the barrel 1-50th part of the shot. Firelocks were first made use of in 1690, when matchlocks were universally disused; but when invented, we cannot ascertain. A firelock is called, by writers of about the middle of the last century, asnaphaan, which being a

Low-Dutch word, seems to indicate its being a Dutch invention.

Fire works. In England it is not lawful for any person to make or cause to be made, or sell or expose to sale, any squibs, rockets, serpents, or other fireworks; or any cases, moulds, or other implements for making the same; or to permit the same to be cast or fired from his house or other place thereto belonging, into any public street or road; or to throw or fire, or be aiding in throwing and firing the same, in any public street, house, shop, river, or highway; and every such offence shall be adjudged a common nuisance. 9 and 10 W. c. 7.

FIRING *in line*, in the military art. According to regulations, the following principal heads constitute firing in line.

The object of fire against cavalry is to keep them at a distance, and to deter them from the attack; as their movements are rapid, a reserve is always kept up. But when the fire commences against infantry, it cannot be too heavy, or too quick while it lasts; and should be continued till the enemy is beaten or repulsed. This may not improperly be called offensive fire.

Defensive fire belongs principally to infantry, when posted on heights, which are to be defended by musquetry. As soldiers generally present too high, and as fire is of the greatest consequence to troops that are on the defensive, the habitual mode of firing should therefore be rather at a low level than a high one.

On these occasions the men are generally drawn up three deep; in which case the front rank kneeling, being the most efficacious as being the most raising, should not be dispensed with when it can be safely and usefully employed.

Firing *by half-battalions, the line advancing*. The left wings halt, and the right ones continue to march 15 paces, at which instant the word march being given to the left wings, the right at the same time are ordered to halt, fire, and load, during which the left march on and pass them till the right wings, being loaded and shouldered, receive the word march, on which the left ones halt, fire, &c. and thus they alternately proceed.

Firing *by half-battalions, the line retiring*. The right wings are ordered to halt, front, and when the left wings have gained fifteen paces, and have received the word halt, front, the right wings are instantly ordered to fire, load, face about, and march fifteen paces beyond the left ones, where they receive the word halt, front, on which the left wings fire, &c. and thus alternately proceed.

It is observed in the official rules and regulations, that in addition to the battalion directions, there must be a regulating battalion named, by the half-battalions of which each line will move, halt, and fire: the commander of each line will be with such half-battalion, and in giving his several commands must have an attention to the general readiness of the line, especially after loading, that the whole are prepared to step off together at the word march. The firing of the advanced wing succeeds the march, or the halt, front, of the retired wing instantly; and each half-battalion fires independant and quick, so that no unnecessary pauses being made betwixt the firing words, the fire of the line should be that of a volley as much as possible; and the whole being thereby loaded together, will be ready for the next command of movement. In these firings of the line advancing or retiring, the two first ranks will fire standing, and the rear rank support their arms.

In this manner also may the alternate battalions of a line advance or retire, and when the whole are to form, and that the last line moves up to the first, every previous help of advanced persons will be given to ensure its correctness.

Fire *in line advancing*, is when the infantry marches in line to attack the enemy, and in advancing makes use of its fire. On these occasions it is better to fire the two first ranks only standing, reserving the third, than to make the front rank kneel and to fire the whole; but when it is necessary to fire at a considerable distance, or on a retiring enemy, volleys may be given by the three ranks, the front one kneeling.

Firing *by platoons*, is practised when a line is posted, or arrives at a fixed situation. In this position, battalions fire independantly of one another, and the fire generally commences from the centre of each. The first fire of each battalion must be regular, and at established pauses and intervals; after which each platoon may continue to fire as soon as it is loaded, independant, and as quick as possible.

Firing *by files*, is generally used behind a parapet, hedge, or abbatis. In this situation the two first ranks only can fire, and that must be by the two men of the same file always firing together, with coolness and deliberation. When, however, the parapet hedge, or abbatis, is but a little raised, platoon firing may be resorted to.

Olique Firing *by battalions*, or otherwise, according to the ground, is extremely advantageous when it is found expedient to give an oblique direction to part of a line, or when it is discovered that their fire can in this manner be thrown against the opening of a defile, the flanks of a column, or against cavalry or infantry that direct their attack on some particular battalion or portion of the line.

Oblique-firing, is either to the right and left, or from the right and left to the centre, depending entirely on the situation of the object to be fired against. The Prussians have a particular contrivance for this purpose: if they are to level to the right, the rear ranks of every platoon are to make two quick but small paces to the left, and the body of each soldier to turn 1-8th of a circle; and are to take the same distance to the right, if they are to level to the left.

When a line halts at its points of firing, no time is to be lost in scrupulous dressing, and the firing is instantly to commence. But when a line halts, and is not to fire, the usual dressings must be attended to; and every thing will depend upon the coolness and attention of the officers and non-commissioned officers.

It should be observed with respect to firings in general, that after the march in front, and halt of the battalion, company or platoon firing ought invariably to begin from the centre, and not from the flank. In other cases, and in successive formations, it may begin from whatever division first arrives, and halts on its own ground.

Square-Firing, is that method of firing where either a regiment or any body of men are drawn up in a square, each front of which is generally divided into four divi-

sions or firings, and the flanks of the square, as being the weakest part, are sometimes covered by four platoons of grenadiers who flank the angles. The first fire is from the right division of each face, the second fire from the left divison of each face, and so on; the grenadiers making the last fire.

Street-FIRING, is the method of firing adopted to defend or scour a street, lane, or narrow pass of any kind; in the execution of which the platoon must be formed according to the width of the place, leaving sufficient room on the flanks for the platoons which have fired, successively to file round to the rear of the others.

Street-FIRING *advancing*. When the column has arrived at the spot where the firing is to commence, the commanding officer from the rear gives the word halt; and the officer commanding the platoon, orders it to make ready, p'sent, fire; recover arms, out-wards face (by half-platoons), quick march.

At the instant the men in the first platoon recover their arms after firing, the second platoon makes ready, and waits in that position till the front is cleared by the first platoon having filed round the flanks towards the rear, when the second advances, with recovered arms, until it receives the word halt, p'sent, fire.

As soon as the platoon which has fired, has got down the flanks, it must form in front of the colours, and prime and load.

Street FIRING *retiring*, is conducted on the same principles, except that the platoons fire without advancing, on the front being cleared by the former platoon filing round the flank.

Another method of street-firing, advancing, generally esteemed more eligible, is, after firing, to wheel out by subdivisions (the pivots having taken a side step to right and left outwards), prime and load, and as soon as the last platoon has passed, file inwards and form.

FIRKIN, an English measure of capacity, for things liquid, being the fourth part of the barrel: it contains 8 gallons of ale, soap, or herrings: and 9 gallons of beer.

FIRLOT, a dry measure used in Scotland. The oat-firlot contains $21\frac{1}{4}$ pints of that country; the wheat-firlot contains about 1211 cubic inches; and the barley-firlot 31 standard pints. Hence it appears that the Scotch wheat-firlot exceeds the English bushel by 33 cubic inches.

FIRST, a word applied to the upper part in a duet, trio, quartet, &c. either vocal or instrumental; also to the upper part of each kind in overtures, symphonies, concertos, and other full pieces. Such parts are called first, because they generally express the air; and from their superior acuteness possess a pre-eminence in the combined effect.

In the score the first part always occupies the stave immediately above that in which the second is written; the second, the stave immediately over that which contains the third, and so on.

FIRST-FRUITS and TENTHS. First fruits are the profits of every spiritual living, for one year, and tenths are the tenth part of the yearly value of such living, given anciently to the pope through all Christendom; but by stat. 26 H. VIII. c. 3, translated to the king, in England, for the ordering whereof there was a court erected, 32 H. VIII. c. 45, but again dissolved anno primo Mariæ, sess. 2. c. 10. And since that time, though these profits are reduced again to the crown, by the stat. 1 Eliz. c. 4, yet was the court never restored, but all matters therein wont to be handled, were transferred to the exchequer.

By stat. 26 H. VIII. the lord chancellor, bishops, &c. are empowered to examine into the value of every ecclesiastical benefice and preferment in their several dioceses; and every clergyman entered on his living before the first-fruits are paid or compounded for, is to forfeit double value. But stat. 1 Eliz. c. 4, ordains, that if an incumbent on a benefice does not live half a year, or is ousted before the year expires, his executors are to pay only a fourth part of the first-fruits; and if he lives the year and then dies, or is ousted in six months after, but half the first-fruits shall be paid; if a year and a half, three quarters of them; and if two years, then the whole; not otherwise. The archbishops and bishops have four years allowed for the payment, and shall pay one quarter every year, if they live so long upon the bishopric: other dignitaries in the church, pay theirs in the same manner, as rectors and vicars.

By 27 H. VIII. c. 8, no tenths are to be paid for the first year, as then the first fruits are due; and by several statutes of Anne, if a benefice is under fifty pounds per annum, clear yearly value, it shall be discharged of the payment of first-fruits and tenths.

The queen also restored to the church, what at first had been thus indirectly taken from it, by remitting the tenths and first-fruits entirely, but by applying these superfluities of the larger benefices, to make up the deficiencies of the smaller; for this purpose she granted a charter, whereby all the revenue of the first-fruits and tenths is vested in trustees for ever, to form a perpetual fund for the augmentation of poor livings under 50*l.* a year. This is usually called queen Anne's bounty, which has been still further regulated by subsequent statutes: though it is to be lamented that the number of such poor livings is so great, that this bounty, extensive as it is, will be slow, and almost imperceptible in its operation; the number of livings under 50*l.* certified by the bishops, at the commencement of the undertaking, being 5597, the revenues of which, on a general average, did not exceed 23*l.* per annum. Black. 285, 286.

FISC, in the civil law, the treasury of a prince. It differs from the ærarium, which was the treasury of the public or people: thus, when the money arising from the sale of condemned persons' goods was appropriated for the use of the public, their goods were said publicari; but when it was destined for the support of the prince, they were called confiscari.

FISCAL, in the civil law, something relating to the pecuniary interest of the prince or people. The officers appointed for the management of the fisc, were called procuratores fisci, and advocati fisci; and among the cases enumerated in the constitutions of the empire, where it was their business to plead, one is against those who have been condemned to pay a fine to the fisc on account of their litigiousness, or frivolous appeals.

FISH, in natural history, constitutes a class of animals which have no feet, but always fins; add to this, that their body is either altogether naked, or only covered

with scales; and that they are aquatic animals, which live mostly, if not always, in water.

They form the 4th class of animals in the Linnæan system, and are divided into six orders, viz. the apodes, the jugulares, the thoraci i, the abdominales, the branchiostegous, and chrondropterygious. See NATURAL HISTORY, PISCES, &c. The animals included in this class are always inhabitants of the waters; are swift in their motions, and voracious in their appetites. They breathe by means of gills, which are generally united by a bony arch, swim by means of radiate fins, and are mostly covered with cartilaginous scales. Besides the parts which they have in common with other animals, they are furnished with a nictitant membrane, and most of them with an air-bladder, by the contraction and dilatation of which, they can raise or sink themselves at pleasure. They are destitute of eyelids, external ears, neck, arms and legs. Their food is mucus, insects, dead bodies, lesser sea-fish, and sea-plants.

The generic character is taken from the shape of the body, covering, structure, figure, and parts of the head; but principally from the branchiostegous membrane. The specific character is taken from the cirri, jaws, fins, spines, lateral lines, digitated appendages, tail and colour. The age of fishes is known by numbering the concentric circles in a transverse section of the backbone, or the concentric circles on the scales. The characters of the six orders are, (1.) apodal, without ventral fins: (2.) jugular, ventral fins before the pectoral: (3.) thoracic, ventral fins under the pectoral: (4.) abdominal, ventral fins behind the pectoral: (5.) branchiostegous, gills destitute of bony rays: (6.) chondropterygious, gills cartilaginous. These two latter orders Linnæus refers to the class amphibia nantes; so that in fact he admits of only 4 orders: under these he enumerates 189 genera, and about 400 species.

FISH. Any person may erect a fish-pond without licence; because it is a matter of profit, and for the increase of victuals. 2 Inst. 199.

Concerning the right and property of fish, it has been held, that where the lord of the manor has the soil on both sides of the river, it is good evidence that he has the right of fishing; but where the river ebbs and flows, and is an arm of the sea, there it is common to all, and he who claims a privilege to himself must prove it. In the Severn, the soil belongs to the owners of the land, on each side; and the soil of the river Thames is in the king, &c. but the fishing is common to all. 1 Mod. 105.

Any person who shall unlawfully break, cut, or destroy, any head or dam of a fish-pond, or wrongfully fish therein, with intent to take or kill fish, shall on conviction at the suit of the king, or of the party, at the assizes or sessions, be imprisoned three months, and pay treble damages, and after the expiration of the three months, shall find sureties for his good behaviour for seven years, or remain in prison till he does. 5 Eliz. c. 21.

If any person shall enter into any park or paddock, fenced in and enclosed, or into any garden, orchard, or yard, adjoining or belonging to any dwelling-house, in or through which park or paddock, garden, orchard, or yard, any stream of water shall run, or wherein shall be any river, stream, pond, pool, moat, stew, or other water, and by any means or device whatsoever, shall steal, take, kill, or destroy, any fish bred or kept in it, without the consent of the owner, or shall be aiding therein, or shall receive or buy any such fish, knowing them to be so stolen or taken as aforesaid, and shall be convicted thereof at the assizes, within six calendar months after the offence shall be committed, he shall be transported for seven years. And any offender, surrendering himself to a justice, or being apprehended or in custody for such offence, or on any other account, who shall make confession thereof, and a true discovery on oath of his accomplice or accomplices, so that such accomplice may be apprehended, and shall on trial give evidence, so as to convict such accomplices, shall be discharged of the offence, so by him confessed.

And if any person shall take, kill, or destroy, or attempt to take, kill, or destroy, any fish in any river, or stream, pond, pool, or other water, (not in any park or paddock, or in any garden, orchard, or yard, adjoining or belonging to any dwelling-house, but in any other inclosed ground, being private property) he shall, on conviction before one justice, on the oath of one witness, forfeit 5*l.* to the owner of the fishery of such river, pond, or other water; and such justice, on complaint upon oath, may issue his warrant to bring the person complained of before him; and if he shall be convicted before such justice, or any other of the county or place, he shall immediately pay the said penalty of 5*l.* to such justice, for the use of the person, as the same is appointed to be paid unto; and in default thereof, shall be committed by such justice to the house of correction, for any time not exceeding six months, unless the forfeiture shall be sooner paid: or such owner of the fishery may, within six calendar months after the offence, bring an action for the penalty in any of the courts of record at Westminster. 5 G. III. c. 14.

FISH, in a ship, a plank or piece of timber, fastened to a ship's mast or yard to strengthen it, which is done by nailing it on with iron spikes, and woulding or winding ropes hard about them.

FISH, *royal*, these are whale and sturgeon, which the king is entitled to, when either are thrown on shore, or caught near the coasts. Plowd. 315.

FISHES, in heraldry, are the emblems of silence and watchfulness, and are borne either upright, embowed, extended, endorsed respecting each other, surmounting one another, fretted, &c. In blazoning fishes, those borne feeding, should be termed devouring; all fishes borne upright and having fins, should be blazoned hauriant; and those borne transverse the escutcheon, must be termed naiant.

FISH-PONDS, those made for the breeding or feeding of fish.

Fish-ponds are no small improvement of watery and boggy lands, many of which are fit for no other use. In making of a pond, its head should be at the lowest part of the ground, that the trench of the flood-gate or sluice, having a good fall, may not be too long in emptying: The best way of making the head secure, is to drive in two or three rows of stakes above six feet long, at about four feet distance from each other, the whole length of the pond-head, of which the first row should be rammed at least about four feet deep. If the bottom is false, the foundation may be laid with quicklime, which slacking, will make it as

hard as a stone. Some lay a layer of lime, and another of earth dug out of the pond, among the piles and stakes; and when these are well covered, drive in others, as they see occasion, ramming in the earth as before, till the pond-head is of the height designed.

The dam should be made sloping on each side, leaving a waste to carry off the over-abundance of water in times of floods or rains; and as to the depth of the pond, the deepest part need not exceed six feet, rising gradually in shoals towards the sides, for the fish to sun themselves, and lay their spawn. Gravelly and sandy bottoms, especially the latter, are best for breeding; and a fat soil, with a white fat water, as the washings of hills, commons, streets, sinks, &c. is best for fattening all sorts of fish. For storing a pond, carp is to be preferred for its quick growth, and great increase, as breeding five or six times a year; but tench for its goodness.

The quantity of fish to be supplied obviously depends upon the quantity of water, which should be divided, where it conveniently can, into five ponds.

Number 5 is intended for breeding, and should be double or treble the size of any of the other ponds. Or if this be inconvenient, there may be two for this purpose. This pond may likewise be the most distant from the house. If the breeding pond should fail to answer this purpose, it will at least serve as a conservatory for fish of small size, to be obtained elsewhere: and indeed, fresh stores in any case will be found desirable. The contents of this pond in carp and tench, or the greatest part, should be taken out annually in September or October, counted in braces, and such as are from five to seven inches long thrown into the pond called No. 4.

The contents of No. 4, when grown one year from the length of five or seven inches, must be put into No. 3. The contents of No. 3, having grown one year from No. 4, must be removed into No. 2. And in like manner, the contents of No. 2, after one year, must be removed into No. 1, which is to contain only such fish as are fit for the table. It is obvious that this pond, for safety and convenience, should be the nearest to the house.

As No. 5 is to be the largest water, so No. 1 is to be the least; the rest of sizes between the two.

The shape of No. 1 should be oblong, for the convenience of the net, and the less disturbance of the fish in taking out what are wanted from time to time.

A book should be kept of the number and size of each kind in every pond.

Carp are fit for the table from three to seven pounds each. Tench from one pound and a half to three pounds each. Perch from three quarters of a pound to one or two pounds, &c.

It is supposed that none of the ponds have a strong current of very cold, acrid, innutritious water.

One acre of water upon a loam, clay, or marl, or any of these with a mixture of gravel, has been st ted to be capable of supporting 2000 pounds weight of fish; the number of the fish making that weight being immaterial.

Carp and tench breed most freely in ponds, or pits newly made. Tench likewise in almost any ponds, where cattle are admitted.

It is evident that perch and pike should not be admitted in any degree in No. 5; but in all the other numbers, besides their own value, they are of important service, provided that they are strictly confined to a size greatly subordinate to that of the carp, or tench. For they destroy not only the accidental spawn of fish which breed, but also several animals, whose food is the same with that of carp and tench, as frogs, newts, &c. Pike above the weight of one or two pounds must not be admitted even amongst carp of the largest size and weight.

With regard to the absolute weight of fish, which any particular pond will support, this can only be determined by observation and experience; as it depends on the different degrees of nutrition in different waters. It is said, that carp and tench in waters which feed well, will before they are aged, double their weight in one year.

The third part of an acre in No. 1 would probably be sufficient for the demand of any family. For, upon the calculation above given, it would support near 700 pounds of fish, which might be divided thus.

50 brace of carp of three pounds each and upwards.
50 brace of tench, of two pounds each and upwards.
50 brace of perch, of one pound each and upwards.

That is, three brace of fish, weighing at least twelve pounds, for the use of every week.

Allowing one acre for No. 5, one-third of an acre for No. 1, and one acre and two-thirds for the intervening numbers, the whole water would be three acres. Upon this calculation the stock of No. 1 at 8*d.* per pound, would be worth 23*l.* 6*s.* 8*d.* per annum, and the expense annually of changing the fish from No. 5 to 4, &c. will not exceed 1*l.* 6*s.* 8*d.* So that the value of each acre would be at lowest 7*l.* 6*s.* 8*d.* annually.

No. 1 being supposed to be near the house, and at no great distance from the garden, if the fish should not thrive sufficiently, which will be seen by the disproportioned size of the head, and the whiteness or paleness of the scales, they may easily be supplied with more food by loose peas from the garden, the sweeping of the granary, worms saved by the gardener in digging, and the offal of the poultry killed for the kitchen; or by letting down the water about two feet, in the spring or summer, where there is a sufficient supply, and sowing the sides with oats, barley, rye, or wheat, very lightly raked in, and then stopping the sluice again.

In ponds already stocked, but not accurately regulated, it would be advisable to begin with that which has the most pike, otherwise with No. 4, or what is intended for No. 4, and throw all the fish under five inches length into No. 5, and the larger, according to their sizes, into the other numbers: and so on with No. 3, 2, 1.

Store-fish procured elsewhere, if taken in summer, should be moved in the night in clean straw, wetted occasionally after they are packed: except perch and pike, which can only be carried in clean pond or river water. In moving fish from one pond to another, they should be first put into tubs of water already prepared for them, and afterwards carried in buckets without water. In taking pike or perch, great care must be observed to avoid raising mud in the water.

In breeding-ponds, all water-fowls, as geese, ducks, &c. should be discouraged; and herons carefully destroyed. If any white fish, as roach, dace, &c. should be found, they are to be taken out; and if there is a spare piece of water for large pike they should be put into it as food for the pike.

Eels may be put with advantage into any except the breeding-ponds, in lieu of perch. The most easy way of taking them is by trimmers laid over night, baited with small fish, not with worms; otherwise they may catch the carp; or a small thief-net may be baited with white fish.

Common sewers and drains from the laundry are prejudicial to fish: so are the leaves falling from trees in great quantities. The use of grains should likewise be avoided in large quantities, as having little nutriment whilst they are thus washed with water.

It seems better for the use of the table, as well as more humane, to kill fish designed for food by an incision with a sharp-pointed penknife, or punctures made with a pin longitudinally into the brain, about half an inch or an inch, according to the size of the fish, above the eyes. As this produces an instantaneous effect, it would probably save the cruel operation of crimping or flaying fish while alive, as in the case of pike and eels.

It is obvious, that this method of regulating fish will apply with its full effect in larger spaces of water: it will likewise apply in a considerable degree to smaller pieces, even where the change is but from a pond for the use of cattle to a single canal in a garden.

In situations near the great inland manufactures, and near the turnpike roads leading from an easy distance to the metropolis, water may be made by this kind of management, with little trouble or expense, to produce a large annual rent.

FISHERMEN. There shall be a master, wardens, and assistants of the fishmongers' company in London chosen yearly, at the next court of the lord mayor and aldermen after the 10th of June, who are constituted a court of assistants; and they shall meet once a month at their common hall to regulate abuses in fishery, register the names of fishermen, and mark their boats, &c.

FISHERY, a place where great numbers of fish are caught.

The principal fisheries for salmon, herring, mackrel, pilchards, &c. are along the coasts of England, Scotland, and Ireland; for cod, on the banks of Newfoundland; for whales, about Greenland; and for pearls, in the East and West Indies.

Fishery, *free*, in law, or an exclusive right of fishing in a public river, is a royal franchise; and is considered as such in all countries where the feodal polity has prevailed: though the making such grants, and by that means appropriating, what it seems unnatural to restrain, the use of running water, was prohibited for the future by Magna Charta; and the rivers that were fenced in king John's time were directed to be laid open, as well as the forests, to be disforested. This opening was extended by the second and third charters of Henry III. to those also that were fenced under Richard I.; so that a franchise of free fishery ought now to be as old at least as the reign of Henry II. This differs, as judge Blackstone observes, from a several of piscary, because he that has a several fishery must also be the owner of the soil, which in a free fishery is not requisite. It differs also from a common fishery, in that the free fishery is an exclusive right; the common is not so; and therefore, in a free fishery, a man has a property in the fish before they are caught; in a common piscary, not till afterwards. Some indeed have considered a free fishery not as a royal franchise, but merely as a private grant of a liberty to fish in the several fishery of the grantor. But the considering such right as originally a flower of the prerogative, till restrained by Magna Charta, and derived by royal grant (previous to the reign of Richard I.) to such as now claim it by prescription, may remove some difficulties in respect to this matter with which our law-books are embarrassed.

Fishery, denotes also the commerce of fish, more particularly the catching them for sale. Were we to enter into a very minute consideration of the fisheries established in England, this article would swell beyond its proper bounds; since fisheries, however, if successful, are not only objects of great commercial importance, but also contribute materially to naval strength, by becoming permanent nurseries for seamen, we shall take notice of some of the most considerable of the British fisheries, and the institutions set on foot for their support.

The situation of the British coasts is the most advantageous in the would for catching fish: the Scottish islands, particularly those to the north and west, lie most commodious for carrying on the fishing trade to perfection. Of these advantages the Scots seem indeed to have been abundantly sensible; for their traffic in herrings is even noticed in history so early as the ninth century. The frequent laws which were enacted in the reigns of James III. IV. and V. discover a steady determined zeal for the benefit of the country, and the full restoration of these fisheries, which the Dutch had found means to engross.

The Scottish fisheries were, however, more particularly indebted to the zealous encouragement of James V. and VI.; the former having planned, and the latter carried into execution, various projects for their extension. The well-meant efforts of James VI. were impeded, and at last wholly suspended, by the disputes which prevailed in the kingdom at that period concerning the succession. Nevertheless the plan was resumed by Charles I. who "ordained an association of the three kingdoms, for a general fishing within the seas and coasts of his majesty's said kingdom; and for the government of the said association, ordained, that there should be a standing committee chosen and nominated by his majesty and his successors from time to time," &c. Several persons of distinction embarked in the design, which the king honoured with his patronage, and encouraged by his bounty. He also ordered Lent to be more strictly observed; prohibited the importation of fish taken by foreigners; and agreed to purchase from the company his naval stores, and the fish for his fleets. Thus the scheme for establishing a fishery in the Hebrides began to assume a favourable aspect; but all the hopes of the adventurers were frustrated by the breaking out of the civil wars, and the very tragical death of their benefactor.

In 1661, Charles II., the duke of York, lord Clarendon, and other persons of rank and fortune, resumed the business of the fisheries with greater vigour than any of their predecessors. For this purpose, the most salutary laws were enacted by the parliaments of England and Scotland; in virtue of which, all materials used in, or depending upon, the fisheries, were exempted from

all duties, excises, or imposts whatever. In England, the company were authorised to set up a lottery, and to have a voluntary collection in all parish churches. Houses of entertainment, as taverns, inns, ale-houses, were to take one or more barrels of herrings, at the stated price of 30*s.* per barrel: also 2*s.* 6*d.* per barrel Dutch was to be paid to the company on all imported fish taken by foreigners. Some families were also invited, or permitted, to settle at Stornaway: the herrings cured by the royal English company gave general satisfaction, and, as mentioned above, brought a high price for those days. Every circumstance attending this new establishment seemed the result of a judicious plan and thorough knowledge of the business, when the necessities of the king obliged him to withdraw his subscription or bounty; which gave such umbrage to the parties concerned, that they soon after dissolved.

In 1677, a new royal company was established in England, at the head of which were the duke of York, the earl of Derby, &c. Besides all the privileges which former companies had enjoyed, the king granted this new company a perpetuity, with power to purchase lands; and also 20*l.* to be paid them annually, out of the customs of the port of London, for every dogger or buss they should build and send out for seven years to come. A stock of 10,980*l.* was immediately advanced, and afterwards 1600*l.* more. This small capital was soon exhausted in purchasing and fitting out busses, with other incidental expenses. The company made, however, a successful beginning; and one of their busses or doggers actually took and brought home 32,000 cod fish; other vessels had also a favourable fishery. Such flattering beginnings might have excited fresh subscriptions, when an unforeseen event ruined the whole beyond the possibility of recovery. Most of the busses had been built in Holland, and manned with Dutchmen; on which pretence the French, who were then at war with Holland, seized six out of seven vessels, with their cargoes and fishing-tackle: and the company being now in debt, sold in 1680 the remaining stores, &c. A number of gentlemen and merchants raised a new subscription of 60,000*l.* under the privileges and immunities of the former charter. This attempt also came to nothing, owing to the death of the king, and the troubles of the subsequent reign.

Soon after the Revolution the business was again resumed upon a more extensive scale; the proposed capital being 300,000*l.* of which 100,000*l.* was to have been raised by the surviving patentees or their successors, and 200,000*l.* by new subscribers. Copies of the letters patent, the constitution of the company, and terms of subscription, were lodged at sundry places in London and Westminster for the perusal of the public, while the subscription was filling. It is probable that king William's partiality to the Dutch fisheries, the succeeding war, or both of these circumstances, frustrated this new attempt; of which we have no farther account in the annals of that reign or since.

The Scottish parliament had also, during the last three reigns, passed various acts for erecting companies and promoting the fisheries; but the intestine commotions of that country, and the great exertions which were made for the Darien establishment, enfeebled all other attempts, whether collectively or by individuals, within that kingdom.

In 1749, his late majesty, having, at the opening of the parliament, warmly recommended the improvement of the fisheries, the house of commons appointed a committee to inquire into the state of the herring and white fisheries, and to consider of the most probable means of extending the same. All ranks of men were elevated with an idea of the boundless riches that would flow into the kingdom from this source. A subscription of 500,000*l.* was immediately filled in the city, by a body of men who were incorporated for 21 years by the name of The Society of the Free British Fishery. Every encouragement was held out by government, both to the society and to individuals, who might embark in this national business. A bounty of 36*s.* per ton was to be paid annually out of the customs, for 14 years, to the owners of all decked vessels or busses, from 20 to 80 tons burden, which should be built after the commencement of the act, for the use of, and fitted out and employed in, the said fisheries, whether by the society or any other persons. At the same time numerous pamphlets and newspaper-essays came forth; all pretending to elucidate the subject, and to convince the public with what facility the herring-fisheries might be transferred from Dutch to British hands. This proved, however, a more arduous task than had been foreseen by superficial speculators. The Dutch were frugal in their expenditures and living; perfect masters of the arts of fishing and curing, which they had carried to the greatest height and perfection. They were in full possession of the European markets; and their fish, whether deserving or otherwise, had the reputation of superior qualities to all others taken in our seas. With such advantages, the Dutch not only maintained their ground against this formidable company, but had also the pleasure of seeing the capital gradually sinking, without having procured an adequate return to the adventurers; notwithstanding various aids and efforts of government from time to time in their favour, particularly in 1757, when an advance of 20*s.* per ton was added to the bounty.

In 1786 the public attention was again called to the state of the British fisheries, by the suggestions of Mr. Dempster in the house of commons, and by different publications that appeared upon the subject; in consequence of which, the minister suffered a committee to be named, to inquire into this great source of national wealth. To that committee it appeared, that the best way of improving the fisheries was, to encourage the inhabitants living nearest to the seat of them to become fishers. And it being found that the north-western coast of the kingdom, though abounding with fish and fine harbours, was utterly destitute of towns, an act was passed for incorporating certain persons therein named, by the style of "The British society for extending of the fisheries, and improving the sea-coasts of this kingdom;" and to enable them to subscribe a joint stock, and therewith to purchase lands, and build thereon free towns, villages, and fishing-stations in the Highlands, and islands in that part of Great Britain called Scotland, and for other purposes. The isle of Mull, Loch-Broom, the Isles of Sky and of Canay, have already

been marked as proper situations for some of these towns. The progress of such an undertaking from its nature must be slow, but still slower when carried on with a limited capital arising from the subscriptions of a few public-spirited individuals. But it is not to be doubted that it will ultimately tend to the increase of the fisheries, and to the improvement of the Highland part of the kingdom. Its tendency is also to lessen the emigration of a brave and industrious race of inhabitants, many of whom have already removed with their families to America.

Anchovy Fishery. The anchovy is caught in the months of May, June, and July, on the coasts of Catalonia, Provence, &c. at which season it constantly repairs up the straits of Gibraltar into the Mediterranean. Collins says they are also found in plenty on the western coasts of England and Wales.

The fishing for them is chiefly in the night-time; when a light being put on the stern of their little fishing-vessels, the anchovies flock round, and are caught in the nets. But then it is asserted to have been found by experience, that anchovies taken thus by fire, are neither so good, so firm, nor so proper for keeping, as those which are taken without fire.

When the fishery is over, they cut off the heads, take out their gall and guts, and then lay them in barrels, and salt them. The common way of eating anchovies is with oil, vinegar, &c. in order to which they are first boned, and the tails, fins, &c. slipped off. Being put on the fire, they dissolve almost in any liquor. Or they are made into sauce by mincing them with pepper, &c. Some also pickel anchovies in small delft or earthen pots, made on purpose, of two or three pounds weight, more or less, which they cover with plaister to keep them the better. Anchovies should be chosen small, fresh pickled, white on the outside and red within. If genuine, they have round backs: for those which are flat or large are often nothing but sardines. Besides these qualities, the pickel, on opening the pots or barrels, should be of a good taste, and not have lost its flavour.

Cod-Fishery. There are two kinds of codfish; the one green or white cod; the other dried or cured cod; though it is all the same fish differently prepared; the former being sometimes salted and barrelled, then taken out for use; and the latter having laid for a competent time in salt, and then dried in the sun or smoke.

The chief fisheries for green cod are in the bay of Canada, on the great bank of Newfoundland, and on the isle of St. Peter, and the isle of Sable; to which places vessels resort from many parts both of Europe and America. They are from 100 to 150 tons burthen, and will catch between 30,000 and 40,000 cod each. The most essential part of the fishery is, to have a master who knows how to cut up the cod, one who is skilled to take off the head properly, and above all a good salter, on which the preserving of them, and consequently the success of the voyage, depend. The best season is from the beginning of February to the end of April; the fish, which in the winter retire to the deepest water, coming then on the banks, and fattening extremely. What are caught from March to June keep well; but those taken in July, August, and September, when it is warm on the banks, are apt to spoil soon. Each fisher takes but one at a time, yet the most expert will take from 350 to 400 in a day; but that is the most, the weight of the fish and the great coldness on the bank fatiguing very much. As soon as the cod are caught, the heads are taken off; they are opened, gutted, and salted; and the salter stows them in the bottom of the hold, head to tail, in beds a fathom or two square; putting layers of salt and fish alternately; but never mixing fish caught on different days. When they have lain thus three or four days to drain off the water, they are placed in another part of the ship, and salted again; where they remain till the vessel is loaded. Sometimes they are cut in thick pieces, and put in barrels for the greater convenience of carriage.

The principal fishery for dry cod is, from Cape Rose to the Bay des Exports, along the coast of Placentia, in which compass there are several commodious ports for the fish to be dried in. These, though of the same kind with the fresh cod, are much smaller, and therefore fitter to keep, as the salt penetrates more easily into them. The fishery of both is much alike; only this latter is most expensive, as it takes up more time, and employs more hands, and yet scarcely half so much salt is spent in this as in the other. The bait is herring, of which great quantities are taken on the coast of Placentia. When several vessels meet and intend to fish in the same port, he whose shallop first touched ground, becomes entitled to the quality and privileges of admiral: he has the choice of his station, and the refusal of all the wood on the coast at his arrival. As fast as the masters arrive, they unrig all their vessels, leaving nothing but the shrouds to sustain the masts; and in the mean time the mates provide a tent on shore covered with branches of trees, with sails over them, with a scaffold of great trunks of pines, 12, 15, 16, and often 20 feet high, commonly from 40 to 60 feet long, and about one-third as much in breadth. While the scaffold is preparing, the crew are fishing; and as fast as they catch, they bring their fish ashore, and open and salt them upon moveable benches; but the main salting is performed on the scaffold. When the fish have taken salt, they wash and hang them to drain on rails; when drained, they are laid on a sort of stages, which are small pieces of wood laid across, and covered with branches of trees, having the leaves stripped off for the passage of the air. On these stages they are disposed, a fish thick, head against tail, with the back uppermost, and are turned carefully every 24 hours. When they begin to dry, they are laid in heaps 10 or 12 thick, in order to retain their warmth; and every day the heaps are enlarged, till they become double their first bulk; then two heaps are joined together, which they turn every day as before; lastly, they are salted again, beginning with those first salted; and being laid in huge piles, they remain in that situation till they are carried on board the ships, where they are laid on the branches of trees disposed for that purpose, upon the ballast, and round the ship, with mats to prevent their contracting any moisture.

The cod supplies four kinds of commodities, viz. the sounds, the tongues, the roes, and the oil, which is extracted from its liver. The first are salted at the fishery, together with the fish, and put in barrels of from 600 to 700 pounds. The tongue are cured in like manner, and brought in barrels of from 400 to 500 pounds. The roes

are also salted in barrels, and serve to cast into the sea to draw fishes together, and particularly pilchards. The oil comes in barrels of from 400 to 520 pounds and is used in dressing leather. In Scotland, they catch a small kind of cod on the coasts of Buchan, and all along the Murray Frith on both sides; as also in the Frith of Forth, Clyde, &c. which is much esteemed. They salt and dry them in the sun upon rocks, and sometimes in the chimney.

Herring-Fishery. The great stations for the fishery are off the Shetland and Western isles, and off the coast of Norfolk, in which the Dutch also share. See the article CLUPEA. There are two seasons for herring-fishing: the first from June to the end of August; and the second in autumn, when the fogs become very favourable for this kind of fishing. The Dutch begin their herring-fishing on the 24th of June, and employ a vast number of vessels called busses, between 54 and 60 tons burden each, and carrying three or four small guns. They never stir out of port without a convoy, unless there are enough together to make about 18 or 20 cannon among them, in which case they are allowed to go in company. Before they go out, they make a verbal agreement, which has the same force as if it was in writing. The regulations of the admiralty of Holland have been partly followed by the French and other nations, and partly improved and augmented with new ones; as, that no fisher shall cast his net within 100 fathoms of another boat: that while the nets are cast, a light shall be kept on the hind part of the vessel: that when a boat is by any accident obliged to leave off fishing, the light shall be cast into the sea: that when the greater part of a fleet leaves off fishing, and casts anchor, the rest shall do the same, &c.

In the late king's reign, very vigorous efforts were made, and bounties allowed, for the encouragement of the British herring-fisheries: the first was, of 30*s.* per ton to every buss of 70 tons and upwards. This bounty was afterwards raised to 50*s.* per ton, to be paid to such adventurers as were entitled to it by claiming it at the place of rendezvous. The busses are from 20 to 90 tons burden, but the best size is 80. A vessel of 80 tons ought to take ten lasts, or 120 barrels of herrings, to clear expenses, the price of the fish to be admitted to be a guinea a barrel. A ship of this size out to have 18 men, and three boats; one of 20 tons should have six men, and every five tons above require an additional hand. To every ton are 250 yards of net; so a vessel of 80 tons carries 20,000 square yards; each net is 12 yards long, and 10 deep; and every boat takes out from 20 to 30 nets, and puts them together, so as to form a long train; they are sunk at each end of the train by a stone, which weighs it down to the full extent: the top is supported by buoys made of sheep-skin, with a hollow stick at the mouth, fastened tight; through this the skin is blown up, and then stopped with a peg, to prevent the escape of the air. Sometimes these buoys are placed at the top of the nets; at other times the nets are suffered to sink deeper, by lengthening the cords fastened to them, every cord being for that purpose 10 or 12 fathoms long. But the best fisheries are generally in more shallow water.

Of the Scots fishery in the Western Isles, the following account is given by Mr. Pennant: "The fishing is always performed in the night, unless by accident. The busses remain at anchor, and send out their boats a little before sunset; which continue out, in winter and summer, till daylight; often taking up and emptying their nets, which they do 10 or 12 times in a night, in case of good success. During winter it is a most dangerous and fatiguing employ, by reason of the greatness and frequency of the gales in these seas, and in such gales are the most successful captures; but by the providence of Heaven, the fishers are seldom lost, and what is wonderful, few are visited with illness. They go out well prepared, with a warm great coat, boots, and skin aprons, and a good provision of beef and spirits. The same good fortune attends the busses, which in the tempestuous season, and in the darkest nights, are continually shifting in these narrow seas from harbour to harbour. Sometimes 80 barrels of herrings are taken in a night by the boats of a single vessel. It once happened, in Loch-Slappan in Skie, that a buss of 80 tons might have taken 200 barrels in one night, with 10,000 square yards of net; but the master was abliged to desist, for want of a sufficient number of hands to preserve the capture. The herrings are preserved by salting after the entrails are taken out. The last is an operation performed by the country people, who get three-halfpence per barrel for their trouble, and sometimes even in the winter, can gain fifteenpence a day. This employs both women and children; but the salting is only entrusted to the crew of the busses. The fish are laid on their backs in the barrels, and layers of salt between them. The entrails are not lost, for they are boiled into an oil; 8000 fish will yield ten gallons, valued at one shilling the gallon. A vessel of 80 tons take out 244 barrels of salt; a drawback is allowed for each barrel used by the foreign or Irish exportation of the fish; but there is a duty per barrel for the home-consumption, and the same for those sent to Ireland. The barrels are made of oak staves, chiefly from Virginia; the hoops from several parts of England, and are either of oak, birch, hazel, or willow; the last from Holland, liable to a duty. The barrels cost about 3*s.* each; they hold from 500 to 800 fish, according to the size of the fish; and are made to contain 32 gallons. The barrels are inspected by proper officers: a cooper examines if they are statutable and good; if faulty he destroys them, and obliges the maker to stand to the loss."

Herrings are cured either white, (*i. e.* pickled) or red. Of the first, those done by the Dutch are the most esteemed, being distinguished into four sorts, according to their sizes; and the best are those that are fat, fleshy, firm, and white, salted the same day they are taken with good salt and well barrelled. The British-cured herrings are little inferior if not equal to the Dutch; for, in spite of all their endeavours to conceal the secret, their method of curing, lasting, or casking the herrings, has been discovered, and is as follows. After they have hauled in their nets, which they drag in the stern of their vessels backwards and forwards in traversing the coast, they throw them upon the ship's deck, which is cleared of every thing for that purpose: the crew is separated into divisions, and each division has a peculiar task; one part opens and guts the herrings, leaving the melts and roes; another cures and salts them, by lining or rubbing their inside with salt; the next packs them, and between each row and division they sprinkle hand-

fuls of salt; lastly, the cooper puts the finishing hand to all, by heading the casks very tight and stowing them in the hold. Red-herrings must lie 24 hours in the brine, inasmuch as they are to take all their salt there; and when they are taken out, they are spitted, that is, strung by the head on little wooden spits, and then hung in a chimney made for that purpose. After which, a fire of brush wood, which yields much smoke but no flame, being made under them, they remain there till sufficiently smoked and dried, and are afterwards barrelled up for keeping.

Lobster-Fishery. Lobsters are taken along the British channel, and on the coast of Norway, whence they are brought to London for sale; and also in the frith of Edinburgh, and on the coast of Northumberland. See the article CANCER. By 10 and 11 W. III. c. 24. no lobster is to be taken under eight inches in length, from the peak of the nose to the end of the middle fin of the tail; and by 9 G. II. cap. 33. no lobsters are to be taken on the coast of Scotland from the first of June to the first of September.

Mackrel-Fishery. The mackrel is a summer fish of passage, found in large shoals, in different parts of the ocean, not far north; but especially on the French and English coasts. The fishing is usually in the months of April, May, and June, and even July, according to the place. See SCOMBER. They enter the English Channel in April, and proceed up to the straits of Dover as the summer advances; so that by June they are on the coasts of Cornwall, Sussex, Normandy, Picardy, &c. where the fish is most considerable. They are an excellent food fresh; and not to be despised when well prepared, pickled, and put up in barrels; a method of preserving them chiefly used in Cornwall. The fish is taken in two ways; either with a line or nets: the latter is the more considerable, and is usually performed in the night-time. The rules observed in the fishing for mackrel are much the same as those already mentioned in the fishery of herrings.

There are two ways of pickling them: the first is, by opening and gutting them, and filling the belly with salt, crammed in as hard as possible with a stick; which done they range them in strata or rows, at the bottom of the vessel, strewing salt between the layers. In the second way, they put them immediately into tubs full of brine, made of fresh water and salt, and leave them to steep, till they have imbibed salt enough to make them keep; after which they are taken out, and barrelled up, taking care to press them close down. Mackrel are not cured or exported as merchandize, except a few by the Yarmouth and Leostoff merchants, but are generally consumed at home; especially in the city of London, and the sea-ports between the Thames and Yarmouth east, and the Land's-end of Cornwall west.

Oyster-Fishery. This fishery is principally carried on at Colchester in Essex; Feversham and Milton in Kent; the Isle of Wight; the Swales of the Medway; and Tenby on the coast of Wales. From Feversham, and the adjacent parts, the Dutch have sometimes loaded a hundred large hoys with oysters in a year. They are also taken in large quantities near Portsmouth, and in all the creeks and rivers between Southampton and Chichester: many of which are carried about by sea to London and to Colchester, to be fed in the pits about Wavenhoe and other places. See OSTREA.

Pilchard-Fishery. The chief pilchard-fisheries are along the coasts of Dalmatia, on the coast of Bretagne, and along the coast of Cornwall and Devonshire. That of Dalmatia is very plentiful: that on the coasts of Bretagne employs annually about 300 ships. Of the pilchard-fishery on the coast of Cornwall, the following account is given by Dr. Borlase: "It employs a great number of men on the sea, training them to naval affairs; employs men, women, and children at land, in salting, pressing, washing, and cleaning; in making boats, nets, ropes, casks, and all the trades depending on their construction and sale. The poor are fed with the offals of the captures, the land with the refuse of the fish and salt; the merchant finds the gains of commission and honest commerce, the fisherman the gains of the fish. Ships are often freighted hither with salt, and into foreign countries with fish, carrying off at the same time part of our tin. Of the usual produce of the great number of hogsheads exported each year for ten years from 1747 to 1756 inclusive, from the four ports of Fowey, Falmouth, Penzance, and St. Ives, it appears that Fowey has exported yearly 1732 hogsheads; Falmouth 14,631 hogsheads and two-thirds; Penzance and Mount's-bay 12,149 hogsheads and one-third; St. Ives 1282 hogsheads; in all amounting to 29,795 hogsheads. Every hogshead for ten years last past, together with the bounty allowed for each hogshead exported, and the oil made out of each hogshead, has amounted one year with another at an average, to the price of 1*l*. 13*s*. 3*d*.: so that the cash paid for pilchards exported has, at a medium, annually amounted to the sum of 49,532*l*. 10*s*." The numbers that are taken at one shooting out of the nets are amazingly great. Mr. Pennant says, that Dr. Borlase assured him, that on the 5th of October 1767, there were at one time inclosed in St. Ives's bay 7000 hogsheads, each hogshead containing 35,000 fish, in all 245 millions.

The pilchards naturally follow the light, which contributes much to the facility of the fishery: the season is from June to September. On the coasts of France they make use of the roes of the cod-fish as a bait; which, thrown into the sea, makes them rise from the bottom, and run into the nets. On the English coasts there are persons posted ashore, who, spying by the colour of the water where the shoals are, make signs to the boats to go among them to cast their nets. When taken, they are brought on shore to a warehouse, where they are laid up in broad piles, supported with backs and sides; and as they are piled, they salt them with bay-salt; in which lying to soak for 30 or 40 days, they run out much blood, with dirty pickel and bittern: then they wash them clean in sea-water; and when dry, barrel and press them hard down to squeeze out the oil, which issues out at a hole in the bottom of the cask.

Salmon-Fishery. The chief salmon-fisheries in Europe are in England, Scotland, and Ireland, in the rivers and sea-coasts adjoining to the river-months. The most distinguished for salmon in Scotland are, the river Tweed, the Clyde, the Tay, the Dee, the Don, the Spey, the Ness, the Bewly, &c. in most of which it is very common, about the height of summer, especially if the weather happens to be very hot, to catch four or five

score of salmon at a draught. The chief rivers in England for salmon are, the Tyne, the Trent, the Severn, and the Thames. The fishing is performed with nets, and sometimes with a kind of locks or weirs made on purpose, which in certain places have iron or wooden grates so disposed, in an angle, that being impelled by any force in a contrary direction to the course of the river, they may give way and open a little at the point of contact, and immediately shut again, closing the angle. The salmon, therefore, coming up into the rivers, are admitted into these grates, which open, and suffer them to pass through, but shut again and prevent their return. The salmon is also caught with a spear, which they dart into him when they see him swimming near the surface of the water. It is customary likewise to catch them with a candle and lanthorn, or wisp of straw set on fire; for the fish naturally following the light, are struck with the spear, or taken in a net spread for that purpose, and lifted with a sudden jerk from the bottom.

"The capture of salmon in the Tweed, about the month of July, (says Mr. Pennant) is prodigious. In a good fishery, often a boat-load, and sometimes near two, are taken in a tide: some few years ago there were above 700 fish taken at one haul, but from 50 to 100 is very frequent. The coopers in Berwick then begin to salt the salmon thoroughly in pipes and other large vessels, and afterwards barrel them to send abroad, having then far more than the London markets can take off their hands.

"Most of the salmon taken before April, or to the setting in of the warm weather, is sent fresh to London in baskets; unless now and then the vessel is disappointed by contrary winds of sailing immediately; in which case the fish is brought ashore again to the coopers' offices, and boiled, pickled, and kitted, and sent to the London markets by the same ship, and fresh salmon put in the baskets in lieu of the stale ones. At the beginning of the season, when a ship is on the point of sailing, a fresh clean salmon will sell from a shilling to eighteen pence a pound; and most of the time that this part of the trade is carried on, the prices are from five to nine shillings per stone; the value rising and falling according to the plenty of fish, or the prospect of a fair or foul wind. Some fish are sent in this manner to London the latter end of September, when the weather grows cool; but then the fish are full of large roes, grow very thin-bellied, and are not esteemed so palatable.

"The season for fishing in the Tweed begins November 30th, but the fishermen work very little till after Christmas: it ends on Michaelmas-day; yet the corporation of Berwick (who are conservators of the river) indulge the fishermen with a fortnight past that time, on account of the change of the style.

"There are on the river 41 considerable fisheries, extending upwards, about 14 miles from the mouth (the others above being of no great value), which are rented for near 5400*l*. per annum: the expense attending the servants' wages, nets, boats, &c. amounts to 5000*l*, more; which together makes up the sum 10,400*l*. Now, in consequence, the produce must defray all, and no less than 20 times that sum of fish will effect it; so that 208,000 salmon must be caught there, one year with another.

"Scotland possesses great numbers of fine fisheries on both sides of that kingdom. The Scotch in early times had most severe laws against the killing of this fish: for the third offence was made capital, by a law of James IV. Before that, the offender had power to redeem his life. They were thought in the time of Henry VI. a present worthy of a crowned head; for in that reign the queen of Scotland sent to the duchess of Clarence 10 casks of salted salmon, which Henry directed to pass duty-free. The salmon are cured in the same manner as at Berwick, and a great quantity is sent to London in the spring; but after that time, the adventurers begin to barrel and export them to foreign countries; but we believe that commerce is far less lucrative than it was in former times, partly owing to the great increase of the Newfoundland fishery, and partly to the general relaxation of the discipline of abstinence in the Romish church.

"Ireland (particularly the north) abounds with this fish; the most considerable fishery is at Cranna, on the river Ban, about a mile and a half from Coleraine. When I made the tour of that hospitable kingdom in 1754, it was rented by a neighbouring gentleman for 620*l*. a year; who assured me, that the tenant, his predecessor, gave 1600*l*. per annum, and was a much greater gainer by the bargain, for the reasons before-mentioned, and on account of the number of poachers who destroy the fish in the fence-months.

"The mouth of this river faces the north; and is finely situated to receive the fish that roam along the coast in search of an inlet into some fresh water, as they do all along that end of the kingdom which opposes itself to the northern ocean. We have seen near Ballicastle, nets placed in the sea at the foot of the promontories that jut into it, which the salmon strike into as they are wandering close to shore; and numbers are taken by that method.

"In the Ban they fish with nets 18 score yards long, and are continually drawing night and day the whole season, which we think lasts about four months, two sets of 16 men each alternately relieving one another. The best drawing is when the tide is coming in; we were told, that in a single draught there were once 840 fish taken.

"A few miles higher up the river is a weir, where a considerable number of fish that escape the nets are taken. We were lately informed, that in the year 1760, about 320 tons were taken in the Cranna fishery."

With regard to the manner of curing salmon when the fish are taken, they are opened along the back, the guts and gills, and the greatest part of the bones removed, so as to make the inside as smooth as possible. They then salt the fish in large tubs for the purpose, where they lie a considerable time soaking in brine; and about October, they pack them close up in barrels, and send them to London or up the Mediterranean. They have also in Scotland a great deal of salmon salted in the common way, which after soaking in brine a competent time is well pressed, and then dried in smoke: this is called kipper, and is chiefly made for home consumption; and if properly cured and prepared, is reckoned very delicious.

Sturgeon-Fishery. See Accipenser. The greatest sturgeon-fishery is in the mouth of the Volga, on the Caspian sea; where the Muscovites employ a great num-

ber of hands, and catch them in a kind of inclosure formed by huge stakes representing the letter Z repeated several times. These fisheries are open on the side next the sea, and close on the other, by which means the fish ascending in its season up the river, is embarrassed in these narrow angular retreats, and is easily killed with a harping-iron. Sturgeons, when fresh, eat deliciously; and in order to make them keep, they are salted or pickled in large pieces, and put in kegs of from 30 to 50 pounds. But the great object of this fishery is the roe, of which the Muscovites are extremely fond, and of which is made the cavear, or kavia, so much esteemed by the Italians. See Cavear.

Tunny-Fishery. The tunny (a species of Scomber, which see) was a fish well known to the ancients, and made a great article of commerce: and there are still very considerable tunny-fisheries on the coasts of Sicily, as well as several other parts of the Mediterranean. The nets are spread over a large space of sea by means of cables fastened to anchors, and are divided into several compartments. The entrance is always directed, according to the season, towards that part of the sea from which the fish are known to come. A man placed upon the summit of a rock high above the water, gives the signal of the fish being arrived; for he can discern from that elevation what passes under the waters infinitely better than any person nearer the surface. As soon as notice is given that the shoal of fish has penetrated as far as the inner compartment, or the chamber of death, the passage is drawn close, and the slaughter begins. The undertakers of these fisheries pay an acknowledgment to the king, or the lord upon whose land they fix the main stay or foot of the tonnara; they make the best bargain they can; and till success has crowned their endeavours, obtain this leave for a small consideration; but the rent is afterwards raised in proportion to their capture.

The tunny enters the Mediterranean about the vernal equinox, travelling in a triangular phalanx, so as to cut the waters with its point, and to present an extensive base for the tides and currents to act against and impel forwards. These fish repair to the warm seas of Greece to spawn, steering their course thither along the European shores, but as they return, approach the African coast; the young fry is placed in the van of the squadron as they travel. They come back from the east in May, and abound on the coast of Sicily and Calabria about that time. In autumn they steer northward, and frequent the neighbourhood of Amalfi and Naples; but during the whole season stragglers are occasionally caught. When taken in May, the usual time of their appearance in the Calabrian bays, they are full of spawn, and their flesh is then esteemed unwholesome, apt to occasion head achs and flatulency; the milts and roes are particularly so at that season. To prevent these bad effects, the natives fry them in oil, and afterwards salt them. The quantity of this fish consumed annually in the two Sicilies almost exceeds the bounds of calculation. From the beginning of May to the end of October it is eaten fresh, and all the rest of the year it is in use salted. The most delicate part is the muzzle. The belly salted was called tarantallum, and accounted a great delicacy by the Romans; its present name is surra. The rest of the body is cut into slices, and put into tubs.

Turbot-Fishery. Turbots grow to a large size, viz. from 23 to 30 pounds. They are taken chiefly off the north coast of England, and others off the Dutch coast. The large turbot (as well as several other kinds of flat fish) are taken by the hook and line, for they lie in deep water; the method of taking them in weirs or staked nets being very precarious. When the fishermen go out to sea, each person is provided with three lines, which are coiled on a flat oblong piece of wicker-work; the hooks being baited, and placed regularly in the centre of the coil. Each line is furnished with 14 score of hooks, at the distance of six feet two inches from each other. The hooks are fastened to the lines upon sneads of twisted horsehair 27 inches in length. When fishing, there are always three men in each coble, and consequently nine of these lines are fastened together, and used as one line, extending in length near three miles, and furnished with 2550 hooks. An anchor and a buoy are fixed at the first end of the line, and one more of each at the end of each man's lines; in all four anchors, which are commonly perforated stones, and four buoys made of leather or cork. The line is always laid across the current. The tides of flood and ebb continue an equal time upon the coast, and, when undisturbed by winds, run each way about six hours; they are so rapid that the fishermen can only shoot and haul their lines at the turn of the tide, and therefore the lines always remain upon the ground about six hours; during which the myxine glutinosa of Linnæus will frequently penetrate the fish that are on the hooks, and entirely devour them, leaving only the skin and bones. The same rapidity of tides prevents their using hand-lines; and therefore two of the people commonly wrap themselves in the sail, and sleep, while the other keeps a strict look-out, for fear of being run down by ships, and to observe the weather. For storms often rise so suddenly, that it is with extreme difficulty they can sometimes escape to the shore, leaving their lines behind.

Besides the coble, the fishermen have also a five-men boat, which is forty feet long and 15 broad, and 25 tons burden; it is so called, though navigated by six men and a boy, because one of the men is commonly hired to cook, &c. and does not share in the profits with the other five. This boat is decked at each end, but open in the middle, and has two large lug-sails. All the able fishermen go in these boats to the herring-fishery at Yarmouth in the end of September, and return about the middle of November. The boats are then laid up till the beginning of Lent, at which time they go off in them to the edge of the Dogger, and other places, to fish for turbot, cod, ling, skates, &c. They always take two cobles on board; and when they come upon their ground, anchor the boat, throw out the cobles, and fish in the same manner as those do who go from the shore in a coble; with this difference only, that here each man is provided with double the quantity of lines, and instead of waiting the return of the tide in the coble, they return to their boat and bait their other lines; thus hawling one set and shooting another every turn of the tide. They commonly run into harbour twice a week to deliver their fish.

The best bait is fresh herring cut in pieces of a proper size: the five-men boats are always furnished with nets for taking them. Next to herrings are the lesser lampreys. The next baits in esteem are small haddocks cut

in pieces, sand worms, and limpets, here called flidders; and when none of these can be had, they use bullock's liver. The hooks are two inches and a half long in the shank, and near an inch wide between the shank and the point. The line is made of small cording, and is always tanned before it is used. Turbots are extremely delicate in their choice of baits; for if a piece of herring or haddock has been twelve hours out of the sea, and then used as bait, they will not touch it.

FISHERY, *Whale*. For the natural history of the whale, the importance of the whale fishery to Britain, and other particulars, see the article BALÆNA.

We shall here only remark, that the legislature, justly considering that trade as of great national importance, bestowed on it at different periods very considerable encouragement. In particular, every British vessel of 200 tons or upwards, bound to the Greenland seas on the whale-fishery, if found to be duly qualified according to the act, obtained a licence from the commissioners of the customs to proceed on such voyage; and on the ship's return, the master and mate making oath that they proceeded on such voyage and no other, and used all their endeavours to take whales, &c. and that all the whale-fins, blubber, oil, &c. imported in their ship, were taken by their crew in those seas, there was allowed 40*s*. for every ton, according to the admeasurement of the ship.

It was afterwards found, however, that so great a bounty was neither necessary to the success of the trade, nor expedient with regard to the public. In 1786, therefore, the acts conferring the said emoluments being upon the point of expiring, the subject was brought under the consideration of parliament; and it was proposed to continue the former measures, but with a reduction of the bounty from 40*s*. to 30*s*. In proposing this alteration, it was stated, "that the sums which this country had paid in bounties for the Greenland fishery amounted to 1,265,461*l*.; that in the last year we had paid 94,858*l*.; and that, from the consequent reduction of the price of the fish, the public at present paid 60 per cent. upon every cargo. In the Greenland fishery there were employed 6000 seamen, and these seamen cost government 13*l*. 10*s*. per man per annum, though we were never able to obtain more than 500 of that number to serve on board our ships of war. Besides, the vast encouragement given to the trade had occasioned such a glut in the market, that it was found necessary to export considerable quantities; and thus we paid a large share of the purchase-money for foreign nations, as well as for our own people, besides supplying them with the materials of several important manufactures." This proposition was opposed by several members, but was finally carried; and the propriety of the measure became very soon apparent. At that time (1786) the number of ships employed from England in the whale-fishery to Davis's Straights and the Greenland seas amounted to 139, besides 15 from Scotland. The proposed alteration took place the next year (1787); and notwithstanding the diminution of the bounty, the trade increased; the number of ships employed the same year from England amounting to 217, and the next year (1788) to 222.

The whale-fishery has of late years been considerably indebted to the introduction of a new kind of harpoon, called the gun-harpoon, which the Society for the Encouragement of Arts have exerted themselves to bring into general use.

FISHING, in general, the art of catching fish, whether by means of nets or spears, or of the line and hook. That which is performed by the net, spear, or harpoon, for fish that go in shoals, has been explained in the preceding articles. That performed by the rod, line, and hook, is usually termed angling; see that article: and for the particular manner of angling for the different kinds of fish, see their respective names. The following, however, require to be mentioned here.

1. The barbel, so called on account of the barb or beard that is under his chaps (see CYPRINUS), though a coarse fish, gives considerable exercise to the angler's ingenuity. They swim together in great shoals, and are at their worst in April, at which time they spawn, but soon come in season: the places whither they chiefly resort, are such as are weedy and gravelly rising grounds, in which this fish is said to dig and root with his nose like a swine. In the summer he frequents the strongest and swiftest currents of waters; as deep bridges, weirs, &c. and is apt to settle himself amongst the piles, hollow places, and moss weeds, and will remain there immoveable: but in winter he retires into deep waters, and helps the female to make a hole in the sands to hide her spawn in, to hinder its being devoured by other fish. He is a very curious and cunning fish; for if his baits are not sweet, clean, well scoured, and kept in sweet moss, he will not bite; but if those are well-ordered and carefully kept, he will bite with great eagerness. The best bait for him is the spawn of a salmon, trout or any other fish; or a piece of chandler's greaves which has been boiled and washed; he will also take a large lob-worm; and if you would have good sport with him, bait the places where you intend to fish with it a night or two before with tallow-chandler's greaves; and the earlier in the morning, or the later in the evening, that you fish, the better it will be. Your rod and line must be both strong and long, with a running plummet on the line; and let a little bit of lead be placed a foot or more above the hook, to keep the bullet from falling on it: so the bait will be at the bottom, where they always bite; and when the fish takes the bait, your plummet will lie and not choke him. By the bending of your rod you may know when he bites, as also with your hand you will feel him make a strong snatch; then strike, and you will rarely fail, if you play him well; but if you manage him not dexterously he will break your line. The best time for fishing is about nine in the morning, and the most proper season is the latter part of May, June, July, and the beginning of August.

2. The bleak is an eager fish, caught with all sorts of worms bred on trees or plants; as also with flies, paste, sheep's blood, &c. Bleak may be angled for with half a score of hooks at once, if they can be all fastened on: he will also in the evening take a natural or artificial fly. If the day is warm and clear, there is no fly so good for him as the small fly at the top of the water, which he will take at any time of the day, especially in the evening. But if the day is cold and cloudy, gentles and caddis are the best; about two feet under water. But the best method is with a drabble, thus: tie 8 or 10 small hooks across a line, two inches above one another; the biggest hook the lowermost, (whereby you may some-

times take a better fish) and bait them with gentles, flies, or some small red worms, by which means you may take half a dozen or more at a time; but when you have them they are not worth the catching, except as a bait for pike, trout, &c.

3. For the bream observe the following directions, which will also apply to carp, tench, or perch fishing. Procure about a quart of large red worms: put them into fresh moss well washed and dried every three or four days, feeding them with fat mould and chopped fennel, and they will be thoroughly scoured in about three weeks.

Let your lines be silk, and silkworm-gut at bottom; let the floats be either swan quills or goose-quills. Let your plumb be a piece of lead in the shape of a spear, with a small ring at the point of it; fasten the lead to the line, and the line-hook to the lead; about ten or twelve inches space between lead and hook will be enough; and take care the lead be heavy enough to sink the float. Having baited your hook well with a strong worm, the worm will draw the hook up and down in the bottom, which will provoke the bream to bite the more eagerly. It will be best to fit up three or four rods and lines in this manner, and set them as will be directed, and this will afford you much the better sport. Find the exact depth of the water if possible, that your float may swim on its surface directly over the lead; then provide the following ground-bait. Take about a peck of sweet gross-ground-malt, and having boiled it a very little, strain it hard through a bag, and carry it to the water-side, where you have sounded; and into the place where you suppose the fish resort, there throw in the malt by handfuls squeezed hard together, or rather mixed with a little clay, that the stream may not separate it before it comes to the bottom; and be sure to throw it in at least a yard above the place where you intend the hook shall lie, otherwise the stream will carry it down too far. Do this about nine o'clock at night, keeping some of the malt in the bag, and go to the place about three the next morning, but approach very warily, lest you should be seen by any of the fish; for it is said that they have their sentinels watching on the top of the water, while the rest are feeding below. Having baited your hook so that the worm may crawl to and fro, the better to allure the fish to bite, cast it in at the place where you find the fish to stay most, which is generally in the broadest and deepest part of the river, so that it may rest about the middle of your ground-bait. Cast in your second line so that it may rest a yard above that, and a third about a yard below it. Let your rods lie on the bank with some stones to keep them down at the great ends; and then withdraw yourself, yet not so far but that you can have your eye upon all the floats: and when you see one bitten and carried away, do not be too hasty to run in, but give time to the fish to tire himself, and then touch him gently. When you perceive the float sink, creep to the water-side, and give it as much line as you can. If it is a bream or carp, he will run to the other side. Strike him gently, and hold your rod at a bend a little while, but do not pull, for then you will spoil all; but you must tire them before they can be landed, for they are very shy. If there are any carp in the river, it is an even chance that you take one or more of them; but if there are any pike or perch, they will be sure to visit the ground-bait, though they will not touch it, being drawn together by the great resort of the small fish, and until you remove them, it is in vain to think of taking the bream or carp. In this case, bait one of your hooks with a small bleak, roach, or gudgeon, about two feet deep from your float, with a little red worm at the point of your hook, and if a pike is there he will be sure to snap at it. This sport is good till nine o'clock in the morning, and in a gloomy day till night; but do not frequent the place too much, lest the fish grow shy.

4. The carp. A person who angles for carp, must arm himself with abundance of patience, because of their extraordinary subtilty and shyness: they always choose to lie in the deepest places either of ponds or rivers, where there is but a small running stream. Further, observe, that they will seldom bite in cold weather; and you cannot be too early or too late at the sport in hot weather; yet if he bites you need not fear his hold, for he is one of those leather-mouthed fish that have their teeth in the throat. Neither must you forget, in angling for him, to have a strong rod and line; and since he is so very wary, it will be proper to entice him, by baiting the ground with a coarse paste.

He seldom refuses the red worm in March, the caddis in June, or the grasshopper in July, August, and September. This fish, however, does not only delight in worms, but also in sweet paste, of which there is great variety; the best is made of honey and sugar mixed up with flour, some veal minced fine, and a little cotton, or white wool to make it adhere to the hook. Some of it ought to be thrown into the water a few hours before you begin to angle; neither will small pellets thrown into the water two or three days before be worse for this purpose, especially if chickens' guts, garbage, or blood mixed with bran and cow-dung, are also thrown in. If you fish with gentles, anoint them with honey. Honey and crumbs of wheat-bread, mixed together, make also a very good paste; or pellets of wheat-bread alone will answer very well.

In taking a carp either in a pond or river, if the angler intends to add profit to his pleasure, he must take a peck of ale-grains, and a good quantity of any blood to mix with the grains; baiting the ground with it where he intends to angle. This food will wonderfully attract the scale-fish, as carp, tench, roach, dace, and bream. Let him angle in a morning, plumbing his ground, and angling for carp with a strong line: the bait must be either paste or a knotted red worm; and by this means he will have sport enough.

5. The pike is caught either by a live bait, which is cruel, or by a trowl, which is a dead or artificial fish, frog, or mouse, fastened to a double hook with some lead to sink it, and gently played by the hand of the angler so as to imitate life. There are two ways of trowling, at snap or at gorge; at snap, the angler strikes the moment the fish springs at the bait; at gorge he suffers him to carry it to his hole, giving it out line as may be required, and swallow it, and strikes him in about ten minutes.

6. Salmon and trout fishing are nearly alike. The trout is caught with a worm, a minnow, or a fly; but the

only elegant sport of this kind is that with the artificial fly, which will be afterwards described.

7. The gudgeon is a small fish, of very delicious taste. It spawns three or four times in the summer season, and feeds in streams, slighting all kinds of flies, but is easily taken with a small red worm, fishing near the ground; and being a leather-mouthed fish, will not easily get off the hook when struck. The gudgeon may be either fished with a float, the hook being on the ground, or by hand, with a running line on the ground without cork or float. He will bite well at wasps, gentles, and cadworms; and a person may fish with two or three hooks at the same time. Before you angle for gudgeons, stir up the sand or gravel with a long pole, which will make them gather to the place, and bite the faster.

8. The tench is a fine fresh-water fish, having very small scales, but large smooth fins, with a red circle about the eyes, and a little barb hanging at each corner of the mouth. It takes more delight among weeds in ponds than in clear rivers, and loves to feed in foul water. His slime is said to have a healing quality for wounded fish, upon which he is called the fishes' physician. When carp, pike, &c. are hurt, it is said they find relief by rubbing themselves against the tench. The season for catching this fish is June, July, and August, very early and late, or even all night, in the still part of the rivers. The bait is a large red worm, at which he bites eagerly, especially if dipped in tar. He delights in all sorts of paste made of strong-scented oils, or tar, or a paste of brown-bread and honey; nor does he refuse the cadworm, lobworm, flagworm, green gentles, cod bait, or soft boiled bread-grain.

9. Smelts are caught at high-tide during the summer and autumn months, with a hook and line, about Limehouse and Poplar. They fish with about ten hooks on the same line, at different depths, each baited with a small piece of smelt, and sometimes two or three are caught at once.

An Epitome of the whole Art of Fishing, wherein are shown at one view, the Harbours, Seasons, and Depths, for catching all sorts of Fish usually angled for; also the various Baits for each, so digested as to contain the Essence of all the Treatises ever written on the subject, exempt from the superfluities, which tend more to perplex than instruct.

Names.	Where found.	Season.	me to angle.	Depth from ground.	Proper Baits. Flies. No.	Pastes No.	Worms. No.	Fish and Insects. No. 8
Bream	rough str. river or mid. pond	April to Mich.	sun-rise to 9 3 to sun-set	touch ground	——	1 3	1 to 7	No. 8
Barbel	gravel-banks in currents under bridges	April to Aug	very early or late	ditto	——	2	2 6 7	——
Bleak	sandy bottom, deep rivers, ships' sterns	May to Oct.	all day	6 inches from bottom	1 2	2	2 3 8	——
Carp	still deep mud bottom, pond or river	May to Aug.	sun-rise to 9 3 to sun-set	3 inches from bottom hot weather, mid-water	——	1 3 4	1 2 3 4 7	——
Chub or Chevin	ditto	May to Dec.	ditto	ditto	1 to 5	2	1 2 4 5	7 8
Dace	sandy bottom, deep rivers, ships' sterns	May to Oct.	all day	6 to 12 inches from bottom	ditto	3 4	1 to 5 & 8	——
Gudgeon	gravel shoals	May to Oct.	ditto	near, or on ground	——	ditto	2 8	——
Pike	near clay-banks	all the year	ditto	mid-water	wh. stro. and snap	line float hook fixt	—— on shore	1 2 3 4 5 6 7
Perch	river in stream / pond deepest part — gravel or weedy bottom	May to Aug. / Aug. to May.	S.-rise to 10 2 to sun-set / mid-day	ditto / 6 inches from bottom	2	1	3 5 7 8	1 6
Pope	deep holes in rivers	May to Oct.	all day	ditto	5	——	all	——
Roach	sandy bottom, deep rivers, ships' sterns	May to Oct.	ditto	6 to 12 inches	1 2 4 5	3 4	ditto	8
Salmon	deep rivers	Mar. to Sept.	8 to 9, 3 to 6	mid-way to the bottom	all large	——	1 5 6 7	1
Smelts	ships' sterns and docks	Apr. to Oct.	all day	mid-way to the bottom variable	all small	——	1 2 5	bits of smelts
Trout	purling stream, and eddies of stony-bottom river	Mar. to Mich.	ditto	cold weather, 6 inches to 9 hot weath. top to mid-wat.	1 to 5	——	1 2 5 to 8	1 8
Tench	mud-bottom, river or pond	all the year	sun-rise to 9 3 to sun-set	cold wea. 3 inch. from bot. hot weather, mid-water	——	1 3 4	1 3 4 to 7	——
Umber or Grayling	clay-bottom, swift stream	all the year	all day	cold weather, 6 to 9 inch hot weath. top to mid-wat	1 to 5	——	all	1 8

Description of proper baits for the several sorts of fish referred to in the foregoing table.—Flies. 1. Stone-fly, found under hollow stones at the side of rivers, is of a brown colour, with yellow streaks on the back and belly, has large wings, and is in season from April to July. 2. Green drake, found among stones by river-sides, has a yellow body ribbed with green, is long and slender, with wings like a butterfly, his tail turns on his back, and from May to midsummer is very useful. 3. Oak-fly found in the body of an old oak, or ash, with its head downwards, is of a brown colour, and excellent from May to September. 4. Palmer-fly or worm, rather a hairy caterpillar, found on leaves of plants, and when it comes to a fly is excellent for trout. 5. Ant-fly, found in ant-hills from June to September. 6. The May-fly is to be found playing by the river-side, especially against rain. See Ephemera. 7. The black-fly is to be found upon every hawthorn after the buds are fallen off.

Almost the only sport in fishing that may be called so, is fly-fishing. The fly is either natural or artificial.

1. Natural flies are innumerable. The most usual

for this purpose are mentioned in the above lines. There are two ways to fish with natural flies; either on the surface of the water, or a little underneath it. In angling for chevin, roach, or dace, move not your natural fly swiftly, when you see the fish make at it; but rather let it glide freely towards him with the stream: but if it be in a still or slow water, draw the fly slowly sideways by him, which will make him eagerly pursue it.

2. The artificial fly is best used when the waters are so troubled by the winds, that the natural fly cannot be seen nor rest upon them. Of artificial flies there are reckoned no less than 12 sorts, of which the following are the principal. 1. For March, the dun-fly, made of dun-wool, and the feathers of the partridge's wing, or the body made of black wool, and the feathers of a black drake. 2. For April, the stone-fly, the body made of black wool, with a little yellow under the wings and tail. 3. For the beginning of May, the ruddy fly, made of red wool, and bound about with black silk, with the feathers of a black capon hanging dangling on his sides next his tail. 4. For June, the greenish fly, the body made of black wool, with a yellow list on either side, the wings taken off the wings of the buzzard, bound with black broken hemp. 5. The moorish fly, the body made of duskish wool, and the wings made of the blackish mail of a drake. 6. The tawny fly, good till the middle of June, the body made of tawny wool, the wings made contrary one against the other, of the whitish mail of a white drake. 7. For July, the wasp-fly, the body made of black wool, cast about with yellow silk, and the wings of drakes' feathers. 8. The steel-fly, good in the middle of July, the body made with greenish wool, cast about with the feathers of a peacock's tail, and the wings made of those of the buzzard. 9. For August, the drake-fly, the body made with black wool cast about with black silk, his wings of the mail of a black drake with a black head. The May-fly is also excellently imitated by the tackle-makers.

The best rules for artificial fly-fishing are; 1. To fish in a river somewhat disturbed with rain: or in a cloudy day, when the waters are moved by a gentle breeze; the south wind is best; and if the wind blows high, yet not so but that you may conveniently guard your tackle, the fish will rise in plain deeps: but if the wind is small, the best angling is in swift streams. 2. Keep as far from the water-side as may be; fish down the stream with the sun at your back, and do not disturb the water with your line. 3. Ever angle in clear rivers with a small fly and slender wings; but in muddy places use a larger. 4. When after rain the water becomes brownish, use an orange fly; in a clear day, a light-coloured fly; a dark fly for dark waters, &c. 5. Let the line be at least twice as long as the rod, unless the river is encumbered with trees. 6. For every sort of fly, have several of the same, differing in colour, to suit with the different complexions of several waters and weathers. 7. Have a nimble eye and active hand, to strike presently with the rising of the fish, or else he will be apt to throw out the hook. 8. Let the fly fall first into the water, and not the line, which will scare the fish. 9. In slow waters, or still places, cast the fly across the river, and let it sink a little in the water, and draw it gently back with the current. Salmon-flies should be made with their wings standing one behind the other, whether two or four. This fish delights in the gaudiest colours that can be; chiefly in the wings, which must be long, as well as the tail. The best wing is the hackle of the golden pheasant.

Pastes.—1. Take the blood of a sheep, and mix it with honey and flour to a proper consistence. 2. Take old cheese grated, a little butter sufficient to work it, and colour it with saffron; in winter use rusty bacon instead of butter. 3. Crumbs of bread chewed or worked with honey or sugar, moistened with gum-water. 4. Bread chewed, and worked in the hand till it becomes stiff, which with a little cotton wool to make it stick on the hook is the best of all.

Worms.—1. The earth-bob, found in sandy ground after ploughing; it is white, with a red head, and bigger than a gentle; another is found in heathy ground with a blue head. Keep them in an earthen vessel well covered, and a sufficient quantity of the mould they harbour in. They are excellent from April to November. 2. Gentles, to be had from putrid flesh; let them lie in wheat-bran a few days before used. 3. Flag-worms, found in the roots of flags: they are of a pale yellow colour, are longer and thinner than a gentle, and must be scoured like them. 4. Cow-dung, bog, or clap-bait, found under cow-dung from May to Michaelmas; it is like a gentle, but larger. Keep it in its native earth like the earth-bob. 5. Cadis-worm, or cod-bait, found under loose stones in shallow rivers: they are always covered with a case of sticks or small gravel, and when drawn out of their case are yellow, bigger than a gentle, with a black or blue head, and are in season from April to July. Keep them in flannel bags. 6. Lob-worm, found in gardens: it is very large, and has a red head, a streak down the back, and a flat broad tail. 7. Marsh worms, found in marshy ground; keep them in moss ten days before you use them: their colour is a blueish red; are a good bait from March to Michaelmas. 8. Brandling or red-worms, found in rotten dunghills and tanners' bark; they are red or rather striped worms, very good for all small fish, have sometimes a yellow tail, or a smaller sort are called tag-tails or gilt-tails, they have not the annular stripe of the brandling.

Fish and Insects.—1. Minnow. 2. Gudgeon. 3. Roach. 4. Dace. 5. Smelt. 6. Yellow frog. 7. Snail slit. 8. Grasshopper.

Floats, are little appendages to the line, used for fishing at bottom, and serving to keep the hook and bait suspended at the proper depth, to discover when the fish have hold of them, &c. Of these there are many kinds: some made of quills, which are the best for slow waters; but for strong streams sound cork, without flaws or holes, bored through with a hot iron, into which is put a quill of a fit proportion, is preferable; the cork should be shaped to a pyramidal form, and made smooth.

The fishing-hook, in general, ought to be long in the shank, somewhat thick in the circumference, the point even and straight; the bend should be in the shank. For setting the hook on, use strong but small silk, laying the hair on the inside of the hook; for if it is on the outside, the silk will fret and cut it asunder.

FISSURE *of the bones*, in surgery, is when they are divided either transversely or longitudinally, not quite

through, but cracked after the manner of glass, by any external force. See SURGERY.

FISTULA, in the ancient music, an instrument of the wind-kind, resembling our flute, or flageolet. See FLUTE.

FISTULA, in surgery, a deep, narrow, and callous ulcer, generally arising from abscesses. See SURGERY.

FISTULARIA, pipe-fish, a genus of the order abdominales. The generic character is, snout cylindric; mouth terminal; body lengthened; gill-membrane seven-rayed.

1. Fistularia tabacaria, or slender fistularia. This highly singular fish seems to have been first described by Marcgrave in his Natural History of Brasil, under the name of petimbuaba. He informs us that it grows to the length of three or four feet, and is of a shape resembling that of an eel, with the mouth toothless and pointed, and the upper lip longer than the lower; the head about nine inches long, from the eyes to the tip of the mouth; the eyes are large and ovate, with a bright-blue pupil and silvery iris, marked on the fore and hind part by a red spot; the skin smooth, like that of an eel, and of a liver-colour marked both above and on each side by a row of blue spots, with greenish ones intermixed. The appearance of the tail is highly singular, being pretty deeply forked, as in the generality of fishes, while from the middle of the furcature springs a very long and thickish bristle or process, of a substance resembling that of a whalebone, and gradually tapering to a fine point. A variety has been observed by Dr. Bloch, in which this part was double, and the snout serrated on each side. This variety, or perhaps sexual difference, appears from the observations of Commerson, detailed by Cepede, to be of a brown colour above, and silvery beneath, but without the blue spots so remarkable on the smooth-snouted kind. The count de Cepede informs us that the spine of this fish is of a very peculiar structure; the first vertebra being of immoderate length, the three next much shorter, and the rest gradually decreasing as they approach the tail: he adds that there are no visible ribs.

This species is said to live chiefly on the smaller fishes, sea-insects, and worms, which the structure of its snout enables it readily to obtain by introducing that part into the cavities of the rocks, under stones, &c. where those animals are usually found.

2. Fistularia Chinensis, or Chinese fistularia. Length from three feet to four feet; general shape like that of an eel, but the body thicker in proportion than in the preceding species: head lengthened into a strong cartilaginous, or rather bony and laterally compressed tubular snout, much broader than in the former species: mouth small; eyes rather large; scales of moderate size, strong, and much resembling in their structure those of the genera perca and chætodon; from the middle of the back to the dorsal fin run several strong, short, and rather distant spines: dorsal and anal fin of similar shape, and placed opposite each other, pretty near the tail, which is short, rounded, and marked by a pair of black stripes; pectoral fins rounded: ventral small, and placed considerably beyond the middle of the body: general colour pale reddish-brown, with several deep or blackish spots on various parts of the body, and three or four pale or whitish longitudinal stripes on each side, from the gills to the tail: fins pale yellow. Native of the Indian seas, preying on worms, sea-insects, &c. Though observed only in the tropical seas, yet its fossil impressions have been found under the volcanic strata of mount Bolca in the neighbourhood of Verona.

3. Fistularia paradoxa, paradoxical fistularia. A small species, described by Seba, and more accurately by Dr. Pallas. Length from two to four inches: body angular, and beset at the interstices of the lines with small spines: head small: eyes large, and situated at the base of the snout, which much resembles that of a syngnathus, and is long, slightly descending, straight, horny, compressed, sharp above, and bicarinated beneath: it is armed on each side, near the base, by a small conic spine. It is a native of the Indian seas.

FIT, in medicine, denotes much the same with paroxysm. See PAROXYSM.

FITS *of easy reflection and transmission.* See OPTICS.

FITCHEE', in heraldry, a term applied to a cross, when the lower end of it is sharpened into a point.

FIXED BODIES are those which bear a considerable degree of heat without evaporating, or losing any of their weight. See CHEMISTRY.

FIXED AIR. See AIR, CARBONIC ACID GAS, and CHEMISTRY.

FIXED STARS. See ASTRONOMY.

FLACOURTIA, a genus of the class and order dioecia polyandria. The male calyx is five-parted; corolla none; stamina very numerous. Female calyx many-leaved; corolla none; germen superior. Styles 5 to 9. Berry many-celled. There is one species, a small tree of Madagascar, bearing an eatable fruit in some degree resembling a plumb.

FLAG, a general name for colours, standards, ancients, banners, ensigns, &c. which are frequently confounded with each other.

The fashion of pointed, or triangular flags, as now used, came from the Mahometan Arabs, or Saracens, upon their seizing of Spain, before which time all the ensigns of war were stretched, or extended on cross pieces of wood, like the banners of a church. The pirates of Algiers, and throughout the coasts of Barbary, bear an hexagonal flag.

FLAG, is more particularly used at sea, for the colours, ancients, standards, &c. borne on the top of the masts of vessels, to notify the person who commands the ship, of what nation it is, and whether it is equipped for war or trade.

The admiral in chief carries his flag on the main top; and the vice-admiral on the fore-top; and the rear-admiral on the mizen top.

When a council of war is to be held at sea, if it is on board the admiral, they hang a flag in the main shrouds; if in the vice-admiral, in the fore shrouds; and if in the rear-admiral, in the mizen shrouds.

Beside the national flag, merchant-ships frequently bear lesser flags on the mizen mast, with the arms of the city where the master ordinarily resides: and on the foremast, with the arms of the place where the person who freights them lives.

To lower, or strike the FLAG, is to pull it down upon the cap, or to take it in, out of respect, or submission, due from all ships or fleets inferior, to those any way justly

their superiors. To lower or strike the flag in an engagement is a sign of yielding.

The way of leading a ship in triumph is to tie the flags to the shrouds or the gallery, in the hind part of the ship, and let them hang down towards the water, and to tow the vessels by the stern.

To heave out the FLAG, is to put out, or put abroad, the flag.

To hang out the white FLAG, is to ask quarter; or it shows when a vessel is arrived on a coast, that it has no hostile intention, but comes to trade, or the like. The red flag is a sign of defiance and battle.

FLAG-OFFICERS, those who command the several squadrons of a fleet, such as the admirals, vice-admirals, and rear-admirals.

The flag-officers in British pay are the admiral, vice-admiral, and rear-admiral, of the white, red, and blue. See the article ADMIRAL.

FLAG-SHIP, a ship commanded by a general or flag-officer, who has a right to carry a flag, in contradistinction to the secondary vessels under its command.

FLAG-STAVES, are staves set on the heads of the top-gallant-masts, serving to let fly, or unfurl, the flag.

FLAGS, in falconry, are the feathers in a hawk's wing, near the principal ones.

FLAG is used for sedge, a kind of rush; and for the upper part of turf, pared off to burn.

FLAG-FLOWER, in botany, a plant called by botanists iris. See IRIS.

Corn-FLAG. See GLADIOLUS.

FLAGELLANTES, *whippers*, in church history, certain enthusiasts in the 13th century, who maintained, that there could be no remission of sins without flagellation, or whipping. Accordingly, they walked in procession, preceded by priests carrying the cross, and publicly lashed themselves, till the blood dropped from their naked backs.

FLAGELLARIA, a genus of the hexandria monogynia class and order of plants: flower petals none; the perianthium is divided into six segments, and the fruit is a roundish berry, containing a single seed. There are two species, shrubs of the East Indies.

FLAGEOLET, or *flajeolet*, a little flute, used chiefly by shepherds, and country people. It is made of box, or any other hard wood, and sometimes of ivory; and has six holes besides that at the bottom, the mouth piece, and that behind the neck.

FLAIL, an instrument for threshing corn. See HUSBANDRY.

A flail consists of the followng parts: 1. The hand-staff, or piece held in the thresher's hand. 2. The swiple, or that part which strikes out the corn. 3. The caplins, or strong double leathers, made fast to the tops of the hand-staff and swiple. 4. The middle-hand, being the leather-thong, or fish-skin, that ties the caplins together.

FLAIR, in the sea-language. When a ship is housed in near the water, so that the work above hangs over too much, it is said to flair over. This makes the ship more roomy aloft, for the men to use their arms.

FLAME, in physiology: when oxygen gas is decomposed slowly, the heat is imperceptible, because the caloric is dissipated as soon as generated. When the decomposition goes on faster, the bodies concerned become sensibly warm. A quicker decomposition of the gas heats the bodies so as to render them red hot, which state is called ignition: and when the process is attended with the production of certain fluids, as hydrogen, &c. and the decomposition of oxygen air affords a sufficient developement of caloric, then the fluids themselves are ignited, and decomposed, which constitutes flame, and is thence termed inflammation. When a candle is first lighted, which must be done by the application of actual flame, a degree of heat is given to the wick sufficient to destroy the affinity of its constituent parts: some of the tallow is instantly melted, volatilized, and decomposed, its hydrogen takes fire, and the candle melts. As this is destroyed by combustion another portion melts, rises and supplies its place, and undergoes a like decomposition. In this way combustion is maintained in a candle. The most brilliant flame is exhibited in oxygen gas, and in this flames of different colours may be produced: thus a mixture of nitrate of strontia and charcoal powder, previously ignited, burns with a rose-coloured flame: one part of boracic acid, and three of charcoal mixed, will burn green: one part of nitrate of barytes and four of charcoal powder burn with a yellow flame: equal parts of nitrate of lime and charcoal powder burn orange-red.

FLAMINGO, in ornithology. See PHŒNICOPTERUS.

FLANEL, or *flannel*, a kind of slight, loose, woollen stuff, composed of a woof and warp, and woven on a loom with two treadles, after the manner of bays. Dr. Black assigns as a reason why flannel and other substances of the kind keep our bodies warm, that they compose a rare and spongy mass, the fibres of which touch each other so slightly, that the heat moves slowly through the interstices, which being filled only with air, and that in a stagnant state, gives little assistance in conducting the heat. Count Rumford, however, has inquired farther into the matter, and finds that there is a relation betwixt the power which the substances usually worn as clothing have of absorbing moisture, and that of keeping our bodies warm. Having provided a quantity of each of those substances mentioned below, he exposed them, spread out upon China plates, for the space of 24 hours to the warm and dry air of a room, which had been heated by a German stove for several months, and during the last six hours had raised the thermometer to 85° of Fahrenheit: after which he weighed equal quantities of the different substances with a very accurate balance. They were then spread out upon a China plate, and removed into a very large uninhabited room upon the second floor, where they were exposed 48 hours upon a table placed in the middle of the room, the air of which was at 45° of Fahrenheit. At the end of this space they were weighed, and then removed into a damp cellar, and placed on a table in the middle of the vault, where the air was at the temperature of 45°, and which by the hygrometer seemed to be fully saturated with moisture. In this situation they were suffered to remain three days and three nights; the vault being all the time hung round with wet linen cloths, to render the air as completely damp as possible. At the end of three days they were weighed, and the weights at the different times were found as in the following table.

	Weight after being dried in the hot room.	Weight after coming out of the cold room.	Weight after remaining 72 hours in the vault.
Sheep's wool	1000 parts	1084	1163
Beaver's fur		1072	1125
The fur of a Russian hare		1065	1115
Eider down		1067	1112
Silk { Raw single thread		1057	1107
Silk { Ravellings of white taffety		1054	1103
Linen { Fine lint		1046	1102
Linen { Ravellings of fine linen		1044	1082
Cotton wool		1043	1089
Ravellings of silver lace		1000	1000

On these experiments our author observes, that though linen, from the apparent ease with which it receives dampness from the atmosphere, seems to have a much greater attraction for water than any other; yet it would appear, from what is related above, that those bodies which receive water in its inelastic form with the greatest ease, or are most easily wet, are not those which in all cases attract the moisture of the atmosphere with the greatest avidity. "Perhaps (says he), the apparent dampness of linen to the touch arises more from the ease with which that substance parts with the water it contains, than from the quantity of water it actually holds: in the same manner as a body appears hot to the touch, in consequence of its parting freely with its heat; while another body, which is really at the same temperature, but which withholds its heat with greater obstinacy, affects the sense of feeling much less violently."

FLANKS *of an army*, are the troops encamped on the right and left, as the flanks of a battalion are the files on the right and left.

FLANKS *of a bastion*, in fortification, that part which joins the face to the curtin. See FORTIFICATION.

FLANKED, in heraldry, is used by the French to express parti per saltier. Coats, however, makes it to be the same with flanch.

FLAT, in the sea-language. To flat in the fore-sail, to hale it in by the sheet, as near the ship's side as possible; which is done when a ship will not fall off from the wind.

FLAT, in music, a character which being placed before a note signifies that the note is to be sung or played half a tone lower than its natural pitch.

FLAT double, or double flat, a character compounded of two flats, and signifying that the note before which it is placed is to be sung or played two semitones lower than its natural pitch.

FLATULENCY. See MEDICINE.

FLAX. See LINUM.

FLEA. See PULEX.

FLEAM, in surgery and farriery, an instrument for letting a horse or other animal blood. See FARRIERY.

FLEECE, the covering of wool, shorn off the bodies of sheep. See WOOL.

FLEECE, *order of the golden*, an order of knighthood instituted by Philip II. duke of Burgundy. These knights at first were twenty-four, besides the duke himself, who reserved the nomination of six more: but Charles V. increased them to fifty. He gave the guardianship of this order to his son Phillip king of Spain, since which the Spanish monarchs are chiefs of the order. The knights had three different mantles ordained them at the grand solemnity, the collar, and fleece.

FLEECY-HOSIERY, a very useful kind of manufacture, in which fine fleeces of wool are interwoven into a cotton piece of the common stocking texture. The following is the specification of the patent granted to Mr. Holland, of Broad-street, Bloomsbury, in the county of Middlesex, for a method of making stockings, socks, waistcoats, and other clothing, for persons afflicted with complaints requiring warmth, and for common use in cold climates, and for making false or downy calves in stockings.

"Having in the common stocking-frame, twisted silk, cotton yarn, flaxen or hempen thread, worsted or woollen yarn, or any such-like twisted or spun materials, begin the work in the common manner of manufacturing hosiery, and having worked one or more course or courses in the common way, begin to add a coating, thus: draw the frame over the arch, and then hang wool or jersey, raw or unspun, upon the beards of the needles, and slide the same off their beards upon their stems, till it comes exactly under the nibs of the sinkers; then sink the jacks and sinkers, and bring forward the frame, till the wool or jersey is drawn under the beards of the needles, and having done this, draw the frame over the arch, and place a thread of spun materials upon the needles (under the nibs of the sinkers), and proceed in finishing the course in the usual way of manufacturing hosiery with spun materials. Any thing manufactured in this way has, on the one side, the appearance of common hosiery, and on the other side the appearance of raw wool. The raw or unspun materials may be worked in with every course, or with every second, third, or other course or courses, in quantity proportioned to the warmth and thickness required. The above-mentioned raw or unspun materials may be fixed also thus: having drawn the frame over the arch, hang them upon the beards of the needles, slide them off the beards upon their stems, and without sinking the jacks and sinkers, draw the frame off the arch, and bring the raw or unspun materials forward under the beards of the needles; then draw the same over the arch, and proceed in finishing the course, as before directed. The said raw or unspun materials may be fixed likewise thus: hang them upon the beards of the needles, without having the frame over the arch, and slide them off their beards upon their stems; then bring forward the frame till the raw or unspun materials are drawn under the beards of the needles, and, having done this, draw the frame over the arch, and proceed in finishing the course as before directed. Hosiery may be coated by any of these methods, not only with wool or jersey, but also with silk, cotton, flax, hemp, hair, or other things of the like nature, raw or unspun, but the method first described fixes them most firmly. The common stocking-frame is mentioned above, but any other frame, upon a similar principle, may answer the purpose. The method of making the false or downy calves in stockings, is by working raw or unspun wool, or jersey, or any other raw or unspun materials, into the calves of stockings, in the different

methods before described, and to any required form or thickness." The latter use to which this invention is applied, we may be allowed to say, is somewhat ludicrous.

FLEET, commonly implies a company of ships of war, belonging to any prince or state; but sometimes it denotes any number of trading-ships, employed in a particular branch of commerce.

In sailing, a fleet of men of war is usually divided into three squadrons; the admiral's, the vice-admiral's, and the rear-admiral's squadron, all which, being distinguished by their flags and pendants, are to put themselves, and as near as may be, to keep themselves in their customary places, viz. the admiral, with his squadron, to sail in the van, that so he may lead the way to all the rest in the day-time, by the sight of his flag on the maintopmast-head; and in the night-time by his lights or lanterns. The vice-admiral and his squadron are to sail in the centre, or middle of the fleet. The rear-admiral, and the ships of his squadron, to bring up the rear. But sometimes other divisions are made; and those composed of the lighter ships and best sailers, are placed as wings to the van, centre, and rear.

Merchant-fleets generally take their denomination from the place they are bound to, as the Turkey fleet, East India fleet, &c. These, in time of peace, go in fleets for their mutual aid and assistance: in time of war, besides this security, they likewise procure convoys of men of war, either to escort them to the places whither they are bound, or only a part of the way, to a certain place or latitude, beyond which they are judged out of danger of privateers, &c.

Fleet, a prison in London, to which persons are committed for contempt of the king and his laws, particularly of his courts of justice: or for debt, where any person will not, or is unable to pay his creditors. There are large rules, and a warden belonging to the fleet prison, which had its name from the float or fleet of the river or ditch on the side whereof it stands.

FLESH, in anatomy, a fibrous part of an animal body, soft and bloody, being that of which most of the other parts are composed, and by which they are connected together: or, more properly, it is that part of the body where the blood-vessels are so small, as only to retain blood enough to preserve their colour red.

By chemical analysis it is found that muscular flesh is composed of a great number of fibres or threads, commonly of a reddish or whitish colour; but its appearance is too well known to require any description. Hitherto it has not been subjected to a perfectly accurate chemical analysis. Mr. Thouvenel, indeed, has published a very valuable dissertation on the subject; and it is to him that we are indebted for almost all the facts known concerning the composition of muscle. Some additions have also been made by M. Fourcroy. And Mr. Hatchett has not neglected this part of the subject in his interesting dissertation on animal substances.

It is scarcely possible to separate the muscle from all the other substances with which it is mixed. A quantity of fat often adheres to it closely; blood pervades the whole of it: and every fibre is enveloped in a particular thin membranous matter, which the anatomists distinguish by the name of cellular substance. The analysis of the muscle, then, cannot be supposed to exhibit an accurate view of the composition of pure muscular fibre, but only of muscular fibre not perfectly separated from other substances.

When a muscle is cut in small pieces, and well washed with water, the blood and other liquids contained in it are separated, and part of the muscular substance is also dissolved. The muscle, by this process, is converted into a white fibrous substance, still retaining the form of the original body. The water assumes the colour which results from mixing water with some blood. When heated it coagulates; brown flakes swim on the surface, consisting of albumen combined with the colouring matter of the blood; some fibrina likewise precipitates. If the evaporation is continued, more albumen precipitates, and at last the whole assumes the form of a jelly. When evaporated to dryness, and treated with alcohol, the gelatine thus formed, together with a little phosphat of soda and of ammonia, remain undissolved; but the alcohol dissolves a peculiar extractive matter, first observed by Thouvenel. This matter may be obtained by evaporating the alcohol to dryness. It has a reddish-brown colour, a strong acrid taste, and an aromatic odour. It is soluble both in water and alcohol; and when its watery solution is very much concentrated, it assumes an acid and bitter taste. It swells upon hot coals, and melts, emitting an acid and penetrating smell. It attracts moisture from the air, and forms a saline efflorescence. In a hot atmosphere it becomes sour and putrefies. When distilled it yields an acid partly combined with ammonia.

If the muscle, after being thus treated with cold water, is boiled for a sufficient time in water, an additional portion of the same substances is separated from it. Some albumen collects on the surface in the form of scum, accompanied with melted fat. The water, when sufficiently concentrated by evaporation, assumes the form of a jelly. When evaporated to dryness, and treated with alcohol, the gelatine and phosphoric salts remain, while the extractive matter of Thouvenel is dissolved, and may be obtained by evaporating to dryness. It is by this process that it is procured in a sufficient quantity for examination, cold water abstracting only a very small portion from the muscle.

The muscle, thus treated with water, is left in the state of grey fibres, insoluble in water, and becoming brittle when dry. This substance possesses all the properties of fibrina.

From these facts, ascertained by Thouvenel and Fourcroy, it appears that the muscles are composed chiefly of fibrina, to which they owe their fibrous structure and their form (see Fibrina); and that they contain also

2. Albumen
3. Gelatine
4. Extractive
5. Phosphat of soda
6. Phosphat of ammonia
7. Phosphat of lime and carbonat of ditto.

For the discovery of the last ingredients we are indebted to Mr. Hatchett, who found that 500 parts of beef-muscle left, after combustion, a residuum of 25.6 parts, consisting chiefly of these salts. When muscles

are long boiled in water, Mr. Hatchett found that the greater part of the phosphat of lime, as well as of the alkaline phosphats, was dissolved; for the muscle, after this treatment, when dissolved in nitric acid, yielded scarcely any phosphat of lime; whereas if it was dissolved directly in nitric acid, a precipitate of phosphat of lime was thrown down by ammonia. Hence it would appear, either that the phosphat of lime is united to gelatine, or that it is rendered soluble by means of it. The carbonat of lime still remains after the action of water, and is converted into oxalat when the muscle is treated with nitric acid.

The muscles of different animals differ exceedingly from each other in their appearance and properties, at least as articles of food; but we know little of their chemical differences. The observations of Thouvenel alone were directed to that object, and they are imperfect. The flesh of the ox contains, according to him, the greatest quantity of insoluble matter, and leaves the greatest residuum when dried: the flesh of the calf is more aqueous and mucous: the land and water turtle yields more matter to water than the muscle of the ox; but Thouvenel ascribes the difference to foreign bodies, as ligaments, &c. mixed with the muscle of the turtle: snails yield to water a quantity of matter intermediate between that given by beef and veal: with them the muscles of frogs, cray fish, and vipers, agree nearly in this respect; but the muscles of fresh-water fish, notwithstanding their softness, yield a considerably smaller proportion.

When meat is boiled, it is obvious that the gelatine, the extractive, and a portion of the salts, will be separated, while the coagulated albumen and fibrina will remain in a solid state. Hence the flavour and the nourishing nature of soups is derived from the extractive and gelatine. When meat is roasted, on the other hand, all these substances continue in it, and the taste and odour of the extractive are greatly heightened by the action of the fire. Hence the superior flavour of roasted meat.

FLEVILLEA, a genus of the hexandria order, in the diœcia class of plants. The male calyx and corolla are quinquefid; the stamina five; the nectarium five converging filaments. The female calyx is quinquefid; there are three styli; the fruit a hard trilocular barky apple.

FLEXIBLE, in physics, a term applied to bodies capable of being bent or diverted from their natural figure or direction.

FLEXION, in anatomy, is applied to the motion by which the arm or any other member of the body is bent. It is also applied to the muscles, nerves, &c.

Flexion, or *flexure of curves*. See the article Flexure.

FLEXOR. See Anatomy.

FLEXURE or curves, in the higher geometry, is used to signify that a curve is both concave and convex, with respect to a given right line.

FLIGHT, is evading the course of justice by a man's voluntarily withdrawing himself. On an accusation of treason or felony, or even of petty-larceny, if the jury find that the party fled for the same, he shall forfeit his goods and chattels, although he be acquitted of the offence; for the very flight itself is an offence, carrying with it a strong presumption of guilt, and is at least an endeavour to elude and stifle the course of justice prescribed by the law. But now the jury very seldom find the flight; such forfeiture being looked upon, since the vast increase of personal property, as too large a penalty for an offence, to which a man is prompted by the natural love of liberty. 4 Black. 387.

FLINT. See Silica.

Flint, a stone very useful in modern war, is found in pieces of different sizes, and usually of a figure more or less globular, commonly among chalk, and often arranged in some kind of order.

Its texture is compact. Its fracture smooth, conchoidal. The stones are always covered by a white crust. Specific gravity from 2.58 to 2.63. Colour varies from honey-yellow to brownish-black. Very brittle, and splits into splinters in every direction. Two pieces of flint rubbed smartly together phosphoresce, and emit a peculiar odour. When heated it decrepitates, and becomes white and opaque. When exposed long to the air it often becomes covered with a white crust. A specimen of flint analysed by Klaproth contained,

98.00	silica,
.50	lime,
.25	alumina,
0.25	oxide of iron,
1.00	water.
100.00	

Vauquelin obtained from another,

97	silica,
1	alumina and iron,
98	

Another specimen analysed by Dolomieu was composed of,

97	silica,
1	alumina, and oxide of iron
2	water.
100.	

The whole crust with which flint is enveloped consists of the same ingredients, and a little carbonat of lime. Water is essential to flint; for when it is separated by heat the stone loses its properties.

The manufacture of gun-flints is chiefly confined to England, and two or three departments of France. The operation is exceedingly simple, and a good workman will make 1000 flints a day. The whole art consists in striking the stone repeatedly with a kind of mallet, and bringing off at each stroke a splinter, sharp at one end, and thicker at the other. The splinters are afterwards shaped at pleasure, by laying the line at which it is wished they should break, upon a sharp instrument, and then giving it small blows with a mallet.

FLOAT *of a fishing-line*, the cork or quill that floats or swims above the water.

Float also signifies a certain quantity of timber bound together by rafters and athwart, and put into a river to be conveyed down the stream; and even sometimes to carry burdens down the river with the stream.

Float-boards, those boards fixed to water-wheels of undershot mills, serving to receive the impulse of the

stream, whereby the wheel is carried round. See Mill-work.

FLOOD, among seamen, is when the tide begins to come up, or the water begins to rise: then they call it young flood; after which it is quarter-flood, half-flood, and high-flood.

Flood-mark, the mark which the sea makes on the shore, at flowing-water, and the highest tide: it is also called high-water mark.

FLOOKING, among miners, a term used to express a peculiarity in the load of a mine. The load or quantity of ore is frequently intercepted in its course, by the crossing of a vein of earth or stone, or some different metallic substance; in which case the load is moved to one side, and this transient part of the land is called a flooking.

FLORIN, is sometimes used for a coin, and sometimes for a money of account.

Florin, as a coin, is of different values, according to the different metals and different countries where it is struck. The gold florins are most of them of a very coarse alloy, some of them not exceeding thirteen or fourteen carats, and none of them seventeen and a half. As to silver florins, those of Holland are worth about 1*s.* 8*d.*: those of Genoa were worth 8¼*d.* sterling. See Coin.

FLORINIANS, *floriniania*, in church history, a sect of heretics of the second century, so denominated from their leader Florinus, who made God the author of evil. They are a species of the gnostics, but deny the judgment and resurrection, and hold that our Saviour was not born of a virgin. They were also called Borborites.

FLORIST, *florista*, according to Linnæus, is an author or botanist who writes a treatise called Flora, comprehending only the plants and trees to be found growing naturally in any place. However, in the more common acceptation of the word, florist signifies a person well skilled in flowers, their kinds and cultivation.

FLOS, in chemistry, the most subtile part of bodies, separated from the more gross parts by sublimation, in a dry form. See Chemistry.

FLOTSAM, Jestam, and Lagan. Flotsam is when a ship is sunk or cast away, and the goods float on the sea; jestam is when a ship is in danger of being sunk, and to lighten the ship the goods are cast into the sea, and the ship notwithstanding perishes; and lagan is when the goods so cast into the sea are so heavy that they sink to the bottom, and therefore the mariners fasten to them a buoy or cork, or such other thing that will not sink, to enable them to find them again. 5 Rep. 106. b. The king shall have flotsam, jestam, and lagan, when the ship is lost, and the owners of the goods are not known, but not otherwise. F. N. B. 122. Where the proprietors of the goods may be known, they have a year and a day to claim flotsam.

FLOUR, the meal of wheat-corn, finely ground and sifted.

Flour-mills are put in motion by the application of various forces: sometimes the first mover is wind, at others water, at others the force of steam, at others the muscular energy of animals. The mechanism of the grinding part of most of these is nearly the same, and pretty well understood: we shall here give an account of the construction of the several figures in the plate.

Fig. 1. (Plate LVIII. Flour-mills) represents a common pair of flour-stones; A, is a trundle fixed to a spindle B, so as to turn with it; the lower end of this spindle turns in a brass socket fixed in the beam, CD, called the bridge-tree; and the upper end of this spindle turns in a wooden bush, fixed into the middle of the nether millstone, which lies on the floor, EF. The top part of the spindle, above the bush, is square, and goes into a strong iron cross, *a b c d*, fig. 2, called the crow: the four ends of this crow are let into the under-surface of the running-millstone, shown upside downwards in fig. 2, so that when the spindle is turned by the trundle A, the stone will turn with it. The end, *c*, of the bridge tree, fig. 1, is jointed into the post, G: the other goes through a long mortice in the post, H, and has an iron rod, I, fixed to it; on the top of this are a screw and hand-nut, K, by turning of which the two mill-stones can be brought nearer together, and vice versa, so as to grind finer or coarser. The two stones are enclosed in an octagonal box, LM, which is about two inches more across than the diameter of the running-stone. Upon the top of this box is a frame to support the hopper, N, to which is hung the shoe or spout, O, by a strap fastened to the back of it; to the other end of the shoe a line, *e*, is fastened, the drawing of which regulates the aperture between the shoe and the hopper, and the quantity of corn that comes from the hopper: this is otherwise done by a small shuttle, *f*, in the front of the hopper: to the end of the shoe, O, a small line, *g*, is fastened, the other end of which is tied to a wooden spring, *h*. The top of the spindle, B, has a small square hole in it, into which is put the feeder, P: this feeder, as the spindle turns round, pushes the shoe from it, and it is brought back by the spring, *h*, three times in each revolution of the stone and spindle, and so causes the corn constantly to run down from the hopper, through the upper millstone, and by the motion thereof it gets between the stones, and is ground. The great velocity of the upper or running stone creates a centrifugal force in the corn, and throws it farther from the centre, till it is thrown quite out at the circumference of the stone in the form of flour, and passes through a spout, Q, to a meal-chest below. The grinding surface of both stones, in order to bruise and cut the corn, are hollowed into straight groves, as shown in fig. 2.

Fig. 3, is a wire bolting-machine; A is the riger and band by which it is turned, from a drum in some part of the mill; on its spindle rows of brushes are fixed, as shown in fig. 4. These brushes turn round within a cylindrical frame, CD, fig. 3; withinside of this frame is nailed wire-cloth, which is very fine at the end D, and gets coarser as it goes towards C; this frame is fixed from turning round, by its ends going into the framing of the box in which the whole is contained, and is farther steadied by four chains, EEE, fastened to the top of the box: at one end of the box is a square hole for the feeding-trough, G, to pass through: this trough is loosely connected to the trough H, (which brings the flour from the floor above) by leather nailed round their ends: the trough G is supported on the end of a crooked piece of wood, *a*, moving round a pin as a centre, at *d*; when the

brushes are turned round with a great velocity, the stubs, *e*, in the end of the spindle, shown in fig. 4, move the trough, G, to one side, and its line, *f*, the spring, *c*, immediately pulls it back again. This shakes the flour down through it into the cylinder, CD, and the brushes rubbing it round against the wire, that sort which is fine enough passes through into the hopper, K: the rest passes on in the cylinder, and goes through into the hoppers, L and M, according to the different degrees of fineness, till at last the bran falls out at a hole in the end, into the hopper, N: these hoppers have troughs, connecting with their bottoms, going through the floor, and the mouths of the flour-sacks are hooked to them in the room below, to receive the different sorts of flour and the bran.

Fig. 5 is the common bolting-cloth; A, is the riger turned by a strap; on its axis, within the box, is a reel, fig. 6, over which is put a bag, open at the ends, called the bolting-cloth, CD, in fig. 5, and tied to the reel by its ends; it is woven very fine at the end, D, and gradually gets coarser towards the end, C; the feeding-troughs, G and H, are the same as already described in fig. 4; by the side of the reel are three wooden bars, *ab*, and another behind, fixed in the box by their ends. When the reel is turned with a great velocity, the four arms, *cdef*, fig. 6, shake the trough, G, and cause the flour to run regularly down into the bolting-cloth, and the centrifugal force causes the cloth to swing against the three sticks, *ab*, beats the fine flour through the cloth into the hopper, K, and the other sorts into the hoppers LMN; the bran falls out at the end of the cloth into the hopper, O, and goes through the end of the box and the floor, in a wooden trough, to the end of which a sack is hooked to receive it in the floor beneath. There are troughs from the bottom of the hopper, KLMN, to convey the flour to the sacks, as described in fig. 4.

We shall hereafter, under the article MILLS, give a more detailed account of the theory of mills, and of the means by which they may be worked with the greatest advantage, and with the least expense of power.

FLOWER, *flos*, among botanists and gardeners, the most beautiful part of trees and plants, containing the organs or parts of fructification. See BOTANY.

FLOWERS, *preserving of.* The method of preserving flowers in their natural beauty through the whole year has been much sought after by many people. Some have attempted it by gathering them when dry, and not too much opened, and burying them in dry sand; but this, though it preserves their figure well, takes off from the liveliness of their colour. Muntingius prefers the following method to all others. Gather roses, or other flowers, when they are not yet thoroughly open, in the middle of a dry day: put them into a good earthen vessel glazed within; fill the vessel up to the top with them; and when full, sprinkle them over with some good French wine, with a little salt in it; then set them by in a cellar, tying down the mouth of the pot. After this they may be taken out at pleasure; and on setting them in the sun, or within reach of the fire, they will open as if growing naturally; and not only the colour, but the odour also, will be preserved.

The flowers of plants are by much the most difficult parts to preserve in any tolerable degree of perfection; of which we have instances in all the collections of dried plants, or horti sicci. In these the leaves, stalks, roots, and seeds of the plants, appear very well preserved; the strong texture of these parts making them always retain their natural form, and the colours in many species naturally remaining. But where these fade, the plant is little the worse for use as to knowing the species. But it is very much otherwise in regard to the petals: these are naturally by much the most beautiful parts of the plant to which they belong; but they are so much injured in the common way of drying, that they not only lose, but change their colours one into another, by which means they give occasion to many errors; and they usually also wither up, so as to lose their very form and natural shape. The primrose and cowslip kinds are very eminent instances of the change of colours in the flowers of dried specimens: for those of this class of plants easily dry in their natural shape; but they loose their yellow, and, instead of it, acquire a fine green colour, much superior to that of the leaves in their most perfect state. The flowers of all the violet kind lose their beautiful blue, and become of a dead-white: so that in dried specimens there is no difference between the blue-flowered violet and the white-flowered kinds.

Sir Robert Southwell has communicated to the world a method of drying plants, by which this defect is proposed to be in a great measure remedied, and all flowers preserved in their natural shape, and many in their natural colours. For this purpose, two plates of iron are to be prepared of the size of a large half-sheet of paper, or larger for particular occasions: these plates must be made so thick as not to be apt to bend; and there must be a hole made near every corner for the receiving a screw to fasten them close together. When these plates are prepared, lay in readiness several sheets of paper, and then gather the plants with their flowers when they are quite perfect. Let this be always done in the middle of a dry day; and then lay the plant and its flower on one of the sheets of paper doubled in half, spreading out all the leaves and petals as nicely as possible. If the stalk is thick, it must be pared or cut in half, so that it may lie flat; and if it is woody, it may be peeled, and only the bark left. When the plant is thus expanded, lay round about it some loose leaves and petals of the flower, which may serve to complete any part that is deficient. When all is thus prepared, lay several sheets of paper over the plant, and as many under it; then put the whole between the iron plates, laying the papers smoothly on one, and laying the other evenly over them: screw them close, and put them into an oven after the bread is drawn, and let them lie there two hours. After that, make a mixture of equal parts of aquafortis and common brandy; shake these well together, and when the flowers are taken out of the pressure of the plates, rub them lightly over with a camel's-hair pencil dipped in this liquor; then lay them upon fresh brown paper, and covering them with some other sheets, press them between this and other papers with a handkerchief till the wet of these liquors is dried wholly away. When the plant is thus far prepared, take the bulk of a nutmeg of gum-dragon; put this into a pint of fair water cold, and let it stand 24 hours; it will in this time be wholly dissolved: then dip a fine hair-pencil in this liquor, and with it daub over the back sides of the leaves, and lay them

carefully down on a half-sheet of white paper fairly expanded, and press them down with some more papers over these. When the gum-water is fixed, let the pressure and papers be removed, and the whole work is finished. The leaves retain their verdure in this case, and the flowers usually keep their natural colours. Some care, however, must be taken that the heat of the oven be not too great. When the flowers are thick and bulky, some art may be used to pare off their backs, and dispose the petals in a due order; and after this, if any of them are wanting, their places may be supplied with some of the supernumerary ones dried on purpose; and if any of them are only faded, it will be prudent to take them away, and lay down others in their stead: the leaves may be also disposed and mended in the same manner.

Another method of preserving both flowers and fruit sound through the whole year is also given by the same author. Take saltpetre, one pound; armenian bole, two pounds; clean common sand, three pounds. Mix all well together; then gather fruit of any kind that is not fully ripe, with the stalk to each; put these, one by one, into a wide-mouthed glass, laying them in good order. Tie over the top with an oil-cloth, and carry them into a dry cellar, and set the whole upon a bed of prepared matter of four inches thick in a box. Fill up the remainder of the box with the same preparation; and let it be four inches thick all over the top of the glass, and all round its sides. Flowers are to be preserved in the same sort of glasses, and in the same manner; and they may be taken up after a whole year as plump and fair as when they were buried.

Flower de lis, or *Flower de luce*, in heraldry, a bearing representing the lily, called the queen of flowers, and the true hieroglyphic of royal majesty; but of late it is become more common, being borne in some coats one, in others three, in others five, and in some semee, or spread all over the escutcheon in great numbers. The arms of France are, three flower-de-lis, or, in a field azure. It is observed by antiquarians, that flower de Louis is the proper name, having been borne by St. Louis on his shield, and that it is not a lily but an iris.

FLOWN sheets. in the sea language: a ship is said to sail with flown sheets when her sails are not haled home, or close to the blocks. The sheets are flown; that is, they are let loose, or run as far as they will.

FLUATS, in chemistry, salts first discovered by Scheele; they are distinguished by the following properties: (1) When sulphuric acid is poured upon them, they emit acrid vapours of fluoric acid, which corrode glass. (2) When heated, several of them phosphoresce. (3) They are not decomposed by heat, nor altered by combustibles. (4) They combine with silica by means of heat. Most of them are sparingly soluble in water.

Fluat of lime—flour spar. This mineral is found abundantly in different countries, particularly in Derbyshire. It is both amorphous and crystallized.

The primitive form of its crystals is the regular octahedron; that of its integrant molecules the regular tetrahedron. The varieties of its crystals hitherto observed amount to 9. These are the primitive octahedron; the cube; the rhomboidal dodecahedron; the cubo-octahedron, which has both the faces of the cube and of the octahedron; the octahedron wanting the edges; the cube wanting the edges, and either one face or two faces in place of each.

Werner divides this species into three sub-species.

1. *Earthy.* Colour greenish white or blueish green. Composed of earthy powder, somewhat agglutinated. Moderately heavy. Phosphoresces on hot coals. Found in Hungary in a vein. According to Pelletier, it is composed of

21	lime
15	alumina
31	silica
28	fluoric acid
1	phosphoric acid
1	muriatic acid
1	oxide of iron
1	water
99	

2. *Compact fluor.* Colour greenish grey, often spotted. Found in mass. Greasy. Fracture even, passing to the conchoidal. Scratches calcareous spar. Moderately heavy.

3. *Fluor spar.* The texture of fluat of lime is foliated. Causes single refraction. Very brittle. Specific gravity from 3.0943 to 3.1911. Colours numerous, red, violet, green, reddish yellow, blackish purple. Its powder thrown upon hot coals emits a blueish or greenish light. Two pieces of it rubbed in the dark phosphoresce. It decrepitates when heated. Before the blowpipe it melts into a transparent glass.

It admits of a polish, and is often formed into vases and other ornaments.

FLUENT, in fluxions, the following quantity, or that which is continually either increasing, or decreasing, whether line, surface, solid, &c. See Fluxion.

FLUID, in physiology, an appellation given to all bodies whose particles easily yield to the least partial pressure, or force impressed. See Hydrostatics.

FLUIDITY, is that state or affection of bodies which exhibits them in a liquid form.

All substances in nature, as far as we are acquainted with them, occur in one or other of the three following states; namely, the state of solids, of liquids, or of elastic fluids or vapours. It has been ascertained, that in a vast number of cases, the same substance is capable of existing successively in each of these states. Thus sulphur is usually a solid body; but when heated to 212° it is converted into a liquid; and at a still higher temperature (about 570°), it assumes the form of an elastic vapour of a deep-brown colour. Water also in our climate is usually a liquid; but when cooled down to 32°, it is converted into a solid body, and at 212° it assumes the form of an elastic fluid.

All solid bodies, a very small number excepted, may be converted into liquids by heating them sufficiently, and on the other hand, every liquid, except spirit of wine, is convertible into a solid body, by exposing it to a sufficient degree of cold. All liquid bodies may, by heating them, be converted into elastic fluids, and a great many solids are capable of undergoing the same change; and, lastly, the number of elastic fluids which by cold are condensible into liquids or solids, is by no means incon-

siderable. These facts have led philosophers to form this general conclusion, "that all bodies, if placed in a temperature sufficiently low, would assume a solid form; that all solids become liquids when sufficiently heated; and that all liquids, when exposed to a certain temperature, assume the form of elastic fluids." The state of bodies then depends upon the temperature in which they are placed; in the lowest temperatures they are all solid, in the higher temperatures they are converted into liquids, and in the highest of all they become elastic fluids. The particular temperatures at which bodies undergo those changes, are exceeding various, but they are always constant for the same bodies. Thus we see that heat produces changes on the state of bodies, converting them all, first into liquids, and then elastic fluids.

I. When solid bodies are converted by heat into liquids, the change in some cases takes place at once. There is no interval between solidity and liquidity; but in other cases a very gradual change may be perceived; the solid becomes first soft, and it passes slowly through all the degrees of softness, till at last it becomes perfectly fluid. The conversion of ice into water is an instance of the first change, for in that substance there is no intervening state between solidity and fluidity. The melting of glass, of wax, and of tallow, exhibits instances of the second kind of change; for these bodies pass through every possible degree of softness before they terminate in perfect fluidity. In general, those solid bodies which crystallize or assume regular prismatic figures, have no interval between solidity and fluidity, while those that do not usually assume such shapes have the property of appearing successively in all the intermediate states.

Solid bodies never begin to assume a liquid form till they are heated to a certain temperature; this temperature is constant in all. In the first class of bodies it is very well defined; but in the second, though it is equally constant, the exact temperature of fluidity cannot be pointed out with such precision on account of the intimate number of shades of softness through which the bodies pass before they acquire their greatest possible fluidity. But even in these bodies we can easily ascertain that the same temperature always produces the same degree of fluidity. The temperature at which this change from solidity to liquidity takes place, receive different names according to the usual state of the body thus changed. When the body is usually observed in a liquid state, we call the temperature at which it assumes the form of a solid, its freezing point, or congealing point. Thus the temperature in which water becomes ice, is called the freezing point of water; on the other hand, when the body is usually in the state of a solid, we call the temperature at which it liquifies its melting point: thus, 212° is the melting point of sulphur, 442° the melting point of tin.

The following table contains a list of the melting points of a considerable number of solid bodies.

Substance.	Melting point.
Lead	594°
Bismuth	576
Tin	442
Sulphur	212
Wax	142
Spermaceti	133
Phosphorus	100
Tallow	92
Oil of anise	50
Olive-oil	36
Ice	32
Milk	30
Vinegar	28
Blood	25
Oil of bergamot	23
Wines	20
Oil of turpentine	14
Sulphuric acid	36
Mercury	39
Liquid ammonia	46
Ether	46
Nitric acid	66

Before Dr. Black began to deliver his chemical lectures in Glasgow in 1757, it was universally supposed that solids were converted into liquids by a small addition of heat, after they had been once raised to the melting point, and that they returned again to the solid state on every small diminution of the quantity of heat necessary to keep them at that temperature. An attentive view of the phenomena of liquefaction and solidification gradually led this sagacious philosopher to observe their inconsistence with the then received opinions, and to form another, which he verified by direct experiments, and drew up an account of his theory, and the proofs of it, which was read to a literary society in Glasgow on April 23d, 1762; and every year after he gave a detailed account of the whole doctrine in his lectures.

The opinion which he formed was, that when a solid body is converted into a liquid, a much greater quantity of heat enters into it than is perceptible immediately after by the thermometer. This great quantity of heat does not make the body apparently warmer, but it must be thrown into it in order to convert it into a liquid; and this great addition of heat is the principal and most immediate cause of the fluidity induced. On the other hand, when a liquid body assumes the form of a solid, a very great quantity of heat leaves it without sensibly diminishing its temperature; and the state of solidity cannot be induced without the abstraction of this great quantity of heat. Or, in other words, whenever a solid is converted into a fluid, it combines with a certain dose of caloric, without any augmentation of its temperature; and it is this dose of caloric which occasions the change of the solid into a fluid. When the fluid is converted again into a solid, the dose of caloric leaves it, without any diminution of its temperature; and it is this abstraction which occasions the change. Thus the combination of a certain dose of caloric with ice causes it to become water, and the abstraction of a certain dose of caloric from water causes it to become ice. Water is then a compound of ice and caloric; and in general all fluids are combinations of the solid, to which they may be converted by the application of cold, and a certain dose of caloric.

Such is the opinion concerning the cause of fluidity taught by Dr. Black as early as 1762. Its truth was established by the following experiments:

First. If a lump of ice, at the temperature of 22°, is brought into a warm room, in a very short time it is heated to 32°, the freezing point. It then begins to melt; but the process goes on very slowly, and several hours

elapse before the whole ice is melted. During the whole of that time its temperature continues at 32°; yet as it is constantly surrounded by warm air, we have reason to believe that caloric is constantly entering into it. Now as none of the caloric is indicated by the thermometer, what becomes of it, unless it has combined with that portion of the ice which is converted into water, and unless it is the cause of the melting of the ice?

Dr. Black took two thin globular glasses, four inches in diameter, and very nearly of the same weight. Both were filled with water; the contents of the one was frozen into a solid mass of ice, the contents of the other were cooled down to 33°; the two glasses were then suspended in a large room at a distance from all other bodies, the temperature of the air being 47°. In half an hour the themometer placed in the water-glass rose from 33° to 40° or 7 degrees; the ice was at first 4 or 5 degrees colder than melting snow, but in a few minutes the thermometer applied to it stood at 32°. The instant of time when it reached that temperature was noted, and the whole left undisturbed for ten hours and a half. At the end of that time the whole ice was melted, except a very small spongy mass, which floated at the top, and disappeared in a few minutes. The temperature of the ice water was 40°.

Thus $10\frac{1}{2}$ hours were necessary to melt the ice, and raise the product to the temperature of 40°. During all this time it must have been receiving heat with the same celerity as the water-glass received it during the first half-hour. The whole quantity received then was 21 times 7, or 147°; but its temperature was only 40°: therefore 139 or 140 degrees had been absorbed by the melting ice, and remained concealed in the water into which it had been converted, its presence not being indicated by the thermometer.

That caloric, or heat, is actually entering into the ice, is easily ascertained by placing the hand on a thermometer under the vessel containing it. A current of cold air may be perceived descending from it during the whole time of the process.

But it will be said, perhaps, that the heat which enters into the ice does not remain there, but is altogether destroyed. This opinion is refuted by the following experiment.

Second. If, when the thermometer is at 22°, we expose a vessel full of water at 52° to the open air, and beside it another vessel full of brine at the same temperature, with thermometers in each, we shall find that both of them gradually lose caloric, and are cooled down to 32°. After this the brine (which does not freeze till cooled down to 0°) continues to cool without interruption, and gradually reaches 22°, the temperature of the air, but the pure water remains stationary at 32°. It freezes, indeed, but very slowly; and during the whole process its temperature is 32°. Now, why should the one liquid refuse all on a sudden to give out caloric and not the other? Is it not much more probable that the water, as it freezes, gradually gives out the heat which it had absorbed during its liquefaction; and that this evolution maintains the temperature of the water at 32°, notwithstanding what it parts with to the air during the whole process? We may easily satisfy ourselves that the water while congealing is constantly imparting heat to the surrounding air; for a delicate thermometer suspended above it is constantly affected by an ascending stream of air less cold than the air around. The following experiment, first made by Fahrenheit, and afterwards often repeated by Dr. Black and others, affords a palpable evidence, that such an evolution of caloric actually takes place during congelation.

Third. If, when the air is at 22°, we expose to it a quantity of water in a tall beer-glass, with a thermometer in it and covered, the water gradually cools down to 22° without freezing. It is therefore 10° below the freezing point. Things being in this situation, if the water is shaken, part of it instantly freezes into a spongy mass, and the temperature of the whole instantly rises to the freezing point, so that the water has acquired ten degrees of caloric in an instant. Now whence came these ten degrees? Is it not evident that it must have come from that part of the water which was frozen, and consequently that water in the act of freezing gives out caloric?

From many experiments made on water in these circumstances, it is found that the quantity of ice which forms suddenly on the agitation of water, cooled down below the freezing point, bears always a constant ratio to the coldness of the liquid before agitation. Thus when water is cooled down to 22° very nearly $\frac{1}{14}$ of the whole freezes; when the previous temperature is 27°, about $\frac{1}{28}$ of the whole freezes. In all cases when water is cooled down below 32°, it loses a portion of the caloric which is necessary to constitute its liquidity. The instant that such water is agitated, one portion of the liquid seizes upon the quantity of caloric in which it is deficient, at the expense of another portion, which of course becomes ice. Thus when water is cooled down to 22°, every particle of it wants 10° of the caloric necessary to keep it in a state of liquidity. Thirteen parts of it seize 10 degrees each from the fourteenth part. These thirteen of course acquire the temperature of 32°; and the other part, being deprived of $10 \times 13 = 130$, which with the ten degrees that it had lost before constitute 140°, or the whole of the caloric necessary to keep it fluid, assumes of consequence the form of ice.

Fourth. If these experiments should not be considered as sufficient to warrant Dr. Black's conclusion, the following, for which we are indebted to the same philosopher, puts the truth of his own opinion beyond the reach of dispute. He mixed together given weights of ice at 32°, and water at 190° of temperature. The ice was melted in a few seconds, and the temperature produced was 53°.

The weight of the ice was 119 half-drachms;
That of the hot water 135
of the mixture 254
of the glass vessel 16

Sixteen parts of glass have the same effect in heating cold bodies, as eight parts of equally hot water. Therefore, instead of the 16 half-drachms of glass, eight of water may be substituted, which makes the hot water amount to 143 half-drachms.

In this experiment there were 158 degrees of heat contained in the hot water, to be divided between the ice and the water. Had they been divided equally, and had the whole been afterwards sensible to the thermometer, the

water would have retained $\frac{143}{262}$ parts of this heat, and the ice would have received $\frac{119}{262}$ parts: that is to say, the water would have retained 86°, and the ice would have received 72°; and the temperature after mixture would have been 104°. But the temperature by experiment is found to be only 53°; the hot water lost 137°, and the ice only received an addition of temperature equal to 21°. But the loss of 18° of temperature in the water is equivalent to the gain of 21° in the ice. Therefore 158°—18° = 140° of heat have disappeared altogether from the hot water. These 140° must have entered into the ice, and converted it into water without raising its temperature.

In the same manner, if we take any quantity of ice, or, which is the same thing, snow at 32°, and mix it with an equal weight of water at 172°, the snow instantly melts, and the temperature of the mixture is only 32°. Here the water is cooled 140°, while the temperature of the snow is not increased at all; so that 140° of caloric have disappeared. They must have combined with the snow; but they have only melted it, without increasing its temperature. Hence it follows irresistibly, that ice, when it is converted into water, absorbs and combines with 140° of caloric.

Water, then, after being cooled down to 32°, cannot freeze till it has parted with 140° of caloric; and ice, after being heated to 32°, cannot melt till it has absorbed 140° of caloric. This is the cause of the extreme slowness of these operations. With regard to water, then, there can be no doubt that it owes its fluidity to the caloric which it contains, and that the caloric necessary to give fluidity to ice is equal to 140°.

To the quantity of caloric which thus occasions the fluidity of solid bodies by combining with them, Dr. Black gave the name of latent heat, because its presence is not indicated by the thermometer; a term sufficiently expressive, but other philosophers have rather chosen to call it caloric of fluidity.

Dr. Black and his friends ascertained also, by experiment, that the fluidity of melted wax, tallow, spermaceti, and metals, is owing to the same cause. Landriani proved, that this is the case with sulphur, alum, nitric, and several of the metals; and it has been found to be the case with every substance hitherto examined. We may consider it therefore as a general law, that whenever a solid is converted into a fluid, it combines with caloric, and that this is the cause of its fluidity.

From the experiments of Dr. Irvine, it appears that the caloric of fluidity of spermaceti is 145°

Bees-wax	175
Tin	500.

These are the only substances in which the quantity of caloric, absorbed during fusion, has been ascertained. In all of them we see this rule to hold, that the caloric of fluidity increases with the temperature at which liquidity takes place.

Dr. Black has rendered it exceedingly probable also, or rather he has proved by his experiments and observations, that the softness of such bodies as are rendered plastic by heat, depends upon a quantity of latent heat which combines with them. Metals also owe their malleability and ductility to the same cause. Hence the reason why they become hot and brittle when hammered.

II. Thus it appears, that the conversion of solids into liquids, is occasioned by the combination of a dose of caloric with the solid. But there is another change of state still more remarkable, to which bodies are liable when exposed to the action of heat. Almost all liquids, when raised to a certain temperature, gradually assume the form of an elastic fluid, invisible like air, and possessed of the same mechanical properties. Thus water, by boiling, is converted into steam, an invisible fluid, 1800 times more bulky than water, and as elastic as air. These fluids retain their elastic form as long as their temperature remains sufficiently high; but when cooled down again, they lose that form, and are convented into liquids. All liquids, and even a considerable number of solids, are capable of undergoing this change when sufficiently heated.

With respect to the temperatures at which liquids undergo this change, they may be all arranged under two divisions. There are some liquids which are gradually converted into elastic fluids at every temperature, while others again never begin to assume that change till their temperature reaches a certain point. Water is a well-known example of the first class of bodies. If an open vessel, filled with water, is carefully examined, we find that the water diminishes in bulk day after day, and at last disappears altogether. If the experiment is made in a vessel sufficiently large, and previously exhausted of air, we shall find that the water will fill the vessel in the state of invisible vapour, in whatever temperature it is placed. Alcohol likewise, and ether, and volatile oils, gradually assume the form of an elastic fluid in all temperatures. But sulphuric acid and the fixed oils never begin to assume the form of vapour till they are raised to a certain temperature. Though left in open vessels they lose no perceptible weight; neither does sulphuric acid lose any weight, though kept ever so long in the temperature of boiling water. When liquids gradually assume the form of elastic fluids in all temperatures, they are said to evaporate spontaneously. The second class of liquids want that property altogether.

When all other circumstances are the same, the evaporation of liquids increases with their temperature; and after they are heated to a certain temperature, they assume the form of elastic fluids with great rapidity. If the heat is applied to the bottom of the vessel containing the liquids, as is usually the case, after the whole liquid has acquired this temperature, those particles of it which are next the bottom become an elastic fluid first: they rise up, as they are formed, through the liquid, like air-bubbles, and throw the whole into violent agitation. The liquid is then said to boil. Every particular liquid has a fixed point at which this boiling commences (other things being the same), and this is called the boiling point of the liquid. Thus water begins to boil when raised to 212°. It is remarkable, that after a liquid has begun to boil, it never becomes any hotter, however strong the fire to which it is exposed. A strong heat indeed makes it boil more rapidly, but does not increase its temperature. This was first observed by Dr. Hooke. See Boiling.

It was observed, when treating of the melting point of solids, that it is capable of being varied considerably by altering the situation of the body. Thus water may be cooled down considerably lower than 32°, without freezing. The boiling point is still less fixed, depending en-

tirely on the degree of pressure to which the liquid to be boiled is exposed. If we diminish the pressure, the liquid boils at a lower temperature; if we increase it, a higher temperature is necessary to produce ebullition. From the experiments of professor Robinson, it appears that, in a vacuum, all liquids boil about 145° lower than in the open air under a pressure of 30 inches of mercury; therefore water would boil in vacuo at 67°, and alcohol at 34°. In a Papin's digester, the temperature of water may be raised to 300°, or even 400°, without ebullition: but the instant that this great pressure is removed, the boiling commences with prodigious violence.

The elasticity of all the elastic fluids into which liquids are converted by heat, increases with the temperature; and the vapour formed, when the liquid boils in the open air, possesses an elasticity just equal to that of air, or capable at a medium of balancing a column of mercury 30 inches high. The following very important table, drawn up by Mr. Dalton from his own experiments, exhibits the elasticity of steam, or the vapour of water of every temperature, from —40° to 325°. The elasticities of all the temperatures from 32° to 212° were ascertained by experiment; the rest were calculated by observing the rate at which the elasticity increased or diminished according to the temperature.

TABLE OF THE ELASTICITY OF STEAM.

Temperature.	Force of Vap. in inches of Mercury.	Temperature.	Force of Vap. in inches of Mercury.	Temperature	Force of Vap. in inches of Mercury.
—40°	.013	27°	.168	58°	490
—30	.020	28	.174	59	.507
—20	.030	29	.180	60	.524
—10	.043	30	.186	61	.542
		31	.193	62	.560
0	.064			63	.578
1	.066	32	.200	64	.597
2	.068	33	207	65	616
3	.071	34	.214	66	.635
4	.074	35	.221	67	.655
5	.076	35	.229	68	.676
6	.079	37	.237	69	.698
7	.082	38	.245	70	.721
8	.085	39	.254	71	745
9	.087	40	.263	72	.770
10	090	41	.273	73	796
11	.093	42	.283	74	823
12	.096	43	.294	75	851
13	.100	44	.305	76	.880
14	.104	45	.316	77	.910
15	.108	46	.328	78	940
16	.112	47	3.39	79	.971
17	.116	48	.351	80	1 00
18	.120	49	.363	81	1.04
19	.124	50	.375	82	1 07
20	.129	51	.388	83	1 10
21	.134	52	.401	84	1.14
22	.139	53	.415	85	1.17
23	.144	54	.429	86	1.21
24	.150	55	.443	87	1.24
25	.156	56	.458	88	1.28
26	.162	57	.474	89	1.32

Temperature.	Force of Vap. in inches of Mercury.	Temperature.	Force of Vap. in inches of Mercury.	Temperature.	Force of Vap. in inches of Mercury.
90°	1.36	151°	7.61	212°	30 00
91	1.40	152	7.81		
92	1.44	153	8.01	213	30.60
93	1.48	154	8.20	214	31.21
94	1.53	155	8.40	215	31.83
95	1.58	156	8.60	216	32.46
96	1.63	157	8.81	217	33 09
97	1.68	158	9.02	218	33.72
98	1.74	159	9.24	219	34.35
99	1.80	160	9.46	220	34.99
100	1.86	161	9.68	221	35.63
101	1.92	162	9.91	222	36.25
102	1.98	163	10.15	223	36.88
103	2.04	164	10.41	224	37.53
104	2.11	165	10.68	225	38.20
105	2.18	166	10.96	226	38.89
106	2.25	167	11.25	227	39.59
107	2.32	168	11.54	228	40.30
108	2.39	169	11.83	229	41.02
109	2.46	170	12.13	230	41.75
110	2.53	171	12.43	231	42.49
111	2.60	172	12.73	232	43.24
112	2.68	173	13.02	233	44.00
113	2 76	174	13.32	234	44.78
114	2.84	175	13.62	235	45.58
115	2.92	176	13 92	236	46.39
116	3.00	177	14.22	237	47.20
117	3.08	178	14.52	238	48.02
118	3.16	179	14.83	339	48.84
119	3.25	180	15.15	240	49.67
120	3 33	181	15.50	241	50.50
121	3.42	182	15.86	242	51.34
122	3.50	183	16 23	243	52.18
123	3.59	184	16.61	244	53.03
124	3.69	185	17.00	245	53.88
125	3.79	186	17.40	246	54.68
126	3.89	187	17.80	247	55.54
127	4.00	188	18.20	248	56.42
128	4 11	189	18.60	249	57.31
129	4.22	190	19.00	250	58.21
130	4 34	191	19.42	251	59.12
131	4.47	192	19.86	252	60.05
132	4.60	193	20.32	253	61.00
133	4.73	194	20.77	254	61.92
134	4.86	195	21.22	255	62.85
135	5.00	196	21.68	256	63.76
136	5.14	197	22.13	257	64.82
137	5.29	198	22.69	258	65.78
138	5.44	199	23.16	259	66.75
139	5.59	200	23.64	260	67.73
140	5 74	201	24.12	261	68.72
141	5 90	202	24.61	262	69.72
142	6.05	203	25.10	263	70.73
143	6.21	204	25.61	264	71.74
144	6 37	205	26.13	265	72 76
145	6.53	206	26.66	266	73.77
146	6.70	207	27.20	267	74.79
147	6.87	208	27 74	268	75.80
148	7.05	209	28.29	269	76.82
149	7.23	210	28.84	270	77.85
150	7.42	211	29.41	271	78.89

Temperature.	Force of Vap. in inches of Mercury.	Temperature.	Force of Vap. in inches of Mercury.	Temperature.	Force of Vap. in inches of Mercury.
272°	79.94	290°	100.12	308°	121.20
273	80.98	291	101.23	309	122.37
274	82.01	292	102.45	310	123.53
275	83.13	293	103.63	311	124.69
276	84.33	294	104.80	312	125 85
277	85.47	295	105.97	313	127.00
278	86.50	296	107 14	314	128.15
279	87.63	297	108.31	315	129.29
280	88.75	298	109.48	316	130.43
281	89.87	299	110.64	317	131.57
282	90.99	300	111.81	318	132 72
283	92.11	301	112.98	319	133.86
284	93.23	302	114.15	320	135.00
285	94.35	303	115.32	321	136.14
286	95.48	304	116.50	322	137.28
287	96.64	305	117.68	323	138.42
288	97.80	306	118.86	324	139.56
289	98.96	307	120.03	325	140 70

Mr. Dalton has discovered that the elasticity of every other vapour or steam is precisely the same, with that of the steam of water at the same distance from its boiling point. Thus water boils at 212°; its elasticity at the temperature of 182°, or 30 under its boiling point, we see from the table is 15.86. Alcohol boils at 176°; the elasticity of the steam of alcohol at 146°, or 30° under its boiling point, is likewise 15.86. This very important discovery enables us to ascertain the elasticity of the vapours of all liquids whatever at any temperature, provided their boiling points are known. We have only to find how many degrees the temperature at which the elasticity required is distant from the boiling point of this liquid. The same number of degrees, added to or subtracted from 212°, gives us a temperature, opposite to which in the above table we shall find the elasticity required.

Such are the phenomena of the conversion of liquid into elastic fluids. Dr. Black applied his theory of latent heat to this conversion with great sagacity; and demonstrated, that it is owing to the very same cause as the conversion of solids into liquids; namely, to the combination of a certain dose of caloric with the liquid, without any increase of temperature. The truth of this very important point was established by the following experiments.

First. When a vessel of water is put upon the fire, the water gradually becomes hotter till it reaches 212°; but afterwards its temperature is not increased. Now caloric must be constantly entering from the fire and combining with the water. But as the water does not become hotter, the caloric must combine with that part of it which flies off in the form of steam; but the temperature of the steam is only 212°; therefore the caloric combined with it does not increase its temperature. We must conclude, then, that the change of water to steam is owing to the combination of this caloric; for it produces no other change.

Dr. Black put some water in a tin-plate vessel upon a red-hot iron. The water was of the temperature of 50°; in four minutes it began to boil, and in 20 minutes it was all boiled off. During the first four minutes it had received 162°, or $40\frac{1}{2}$ per minute. If we suppose that it received as much per minute during the whole process of boiling, the caloric which entered into the water and converted it into steam would amount to $40\frac{1}{2} \times 20 =$ 810°. This caloric is not indicated by the thermometer, for the temperature of steam is only 212°; therefore Dr. Black called it latent heat.

Second. Water may be heated in a Papin's digester to 400° without boiling; because the steam is forcibly compressed, and prevented from making its escape. If the mouth of the vessel is suddenly opened while things are in this state, part of the water rushes out in the form of steam, but the greater part still remains in the form of water, and its temperature instantly sinks to 212°; consequently 188° of caloric have suddenly disappeared. This caloric must have been carried off by the steam. Now as only about 1-5th of the water is converted into steam, that steam must contain not only its own 188°, but also the 188° lost by each of the other four parts; that is, it must contain 188° × 5, or about 940°. Steam therefore is water combined with at least 940° of caloric, the presence of which is not indicated by the thermometer. This experiment was first made by Dr. Black, and afterwards with more precision by Mr. Watt.

Third. When hot liquids are put under the receiver of an air-pump, and the air is suddenly drawn off, the liquids boil, and their temperature sinks with great rapidity a considerable number of degrees. Thus water, however hot at first, is very soon reduced to the temperature of 70°, and ether becomes suddenly so cold, that it freezes water placed round the vessel which contains it. In these cases the vapour undoubtedly carries off the heat of the liquid: but the temperature of the vapour is never greater than that of the liquid itself; the heat therefore must combine with the vapour, and become latent.

Fourth. If one part of steam at 212° is mixed with nine parts by weight of water at 62°, the steam instantly assumes the form of water, and the temperature after mixture is 178.6°, consequently each of the nine parts of water has received 116.6° of caloric; of course the steam has lost 9 × 116.6° = 1049.4° of caloric. But as the temperature of the steam is diminished by 33.3°, we must subtract this sum. There will remain rather more than 1000°, which is the quantity of caloric which existed in the steam without increasing its temperature. This experiment cannot be made directly; but it may be made by passing a given weight of steam through a metallic worm, surrounded by a given weight of water. The heat acquired by the water indicates the caloric which the steam gives out during its condensation. From the experiments of Mr. Watt made in this manner, it appears that the latent heat of steam amounts to 940°. The experiments of M. Lavoisier make it rather more than 1000°.

By the experiments of Dr. Black and his friends, it was ascertained, that not only water, but all other liquids during their conversion into vapour, combine with a dose of caloric, without any change of temperature; and that every kind of elastic fluid, during its conversion into a liquid, gives out a portion of caloric without

any change of temperature. Dr. Black's law is then very general, and comprehends every change in the state of a body. The cause of the conversion of a solid into a liquid is the combination of the solid with caloric; that of the conversion of a liquid into an elastic fluid is the combination of the liquid with caloric. Liquids are solids combined with caloric; elastic fluids are liquids combined with caloric. This law, in its most general form, may be stated as follows: whenever a body changes its state, it either combines with caloric, or separates from caloric.

No person will dispute that this is one of the most important discoveries hitherto made in philosophy. Science is indebted for it entirely to the sagacity of Dr. Black. Other philosophers indeed have laid claim to it; but these claims are either without any foundation, or their notions may be traced to Dr. Black's lectures, as their opinions originated many years posterior to the public explanation of Dr. Black's theory in the chemical chairs of Glasgow and Edinburgh.

III. A very considerable number of bodies, both solids and liquids, may be converted into elastic fluids by heat; and as long as the temperature continues sufficiently high, they retain all the mechanical properties of gaseous bodies. It is exceedingly probable, that if we could command a heat sufficiently intense, the same change might be produced on all bodies in nature. This accordingly is the opinion at present admitted by philosophers. But if all bodies are convertible into elastic fluids by heat, it is exceedingly probable that all elastic fluids in their turn might be converted into solids or liquids, if we could expose them to a sufficiently low temperature. In that case, all the gases must be supposed to owe their elasticity to a certain dose of caloric: they must be considered as compounds of caloric with a solid or liquid body. This opinion was first stated by Amontons, and it was supported with much ingenuity both by Dr. Black and Lavoisier, and his associates. It is at present the prevailing opinion; and it is certainly supported not only by analogy, but by several very striking facts.

If its truth is admitted, we must consider all the gases as capable of losing their elasticity by depriving them of their heat: they differ merely from the vapours in the great cold which is necessary to produce this change. Now the fact is, that several of the gases may be condensed into liquids by lowering their temperatures. Oxymuriatic acid gas becomes liquid at a temperature not much under 40°; and at 32° it even forms solid crystals. Ammoniacal gas condenses into a liquid at — 45°. None of the other gases have been hitherto condensed.

It is well known, that the condensation of vapours is greatly assisted by pressure; but the effect of pressure diminishes as the temperature of vapours increases. It is very likely that pressure would also contribute to assist the condensation of gases. It has been tried without effect indeed in several of them. Thus air has been condensed till it was heavier than water; yet it showed no disposition to lose its elasticity. But this may be ascribed to the high temperature at which the experiment was made relative to the point at which air would lose its elasticity.

At the same time it cannot be denied, that there are several phenomena scarcely reconcilable to this constitution of the gases, ingenious and plausible as it is. One of the most striking is the sudden solidification which ensues when certain gases are mixed together. Thus when ammoniacal gas and muriatic acid gas are mixed, the product is a solid salt; yet the heat evolved is very inconsiderable, if we compare it with the difficulty of condensing these gases separately, and the great cold which they endure before losing their elasticity. In other cases too, gaseous bodies unite, and form a new gas, which retains its elasticity as powerfully as ever. Thus oxygen gas and nitrous gas combined form a new gas, namely, nitric acid, which is permanent till it comes into contact with some body on which it can act.

FLUOR-ALBUS. See MEDICINE.

FLUOR-SPAR. See FLUAT of LIME.

The principal use of fluats is for smelting ores, where they act as very powerful fluxes, and on this account are much valued. They are found in various countries, particularly Sweden, and some other northern countries of Europe. From this quality of melting easily in combination with other earthy matters, they have got the name of fluors. "The resemblance between the coloured fluors and the composition made of coloured glass (says Cronstedt), has perhaps contributed not only to the fluors being reckoned of the same value with the coloured quartz crystals, by such collectors as only mind colour and figure, but to their also obtaining a rank among the precious stones in the apothecaries' and druggists' shops." Mr. Fabroni observes, that the combination of calcareous earth with the sparry acid is almost always transparent: it often crystallizes in regular cubes, sometimes single from one line to two inches in diameter, and sometimes of an indeterminate figure. They are sometimes of a blue colour; others are purple like amethysts; some are of a brown colour, others opaque. M. Magellan says, that fluors in general have this singular property, that on being melted by the flame of the blow-pipe, together with gypsum, the product resulting from both is all formed with facets on the outside; but if melted with terra ponde rosa, its surface is quite round or spherical.

FLUORIC ACID. The mineral called fluor, or fusible spar, and in this country Derbyshire spar, was not properly distinguished from other spars till Margraff published a dissertation on it in the Berlin Transactions for 1768. He first proved, that it contained no sulphuric acid, as had been formerly supposed: he then attempted to decompose it, by mixing together equal quantities of this mineral and sulphuric acid, and distilling them. By this method he obtained a white sublimate, which he supposed to be the fluor itself volatilized by the acid. He observed with astonishment, that the glass retort was corroded, and even pierced with holes. Nothing more was known concerning fluor till Scheele published his experiments three years after, by which he proved that it is composed chiefly of lime and a particular acid, which has been called fluoric acid.

The composition of fluoric acid is equally unknown with that of muriatic acid. Mr. Henry tried in vain to decompose it by means of electricity. It is always obtained from fluor spar, in which mineral it is found in abundance. For the investigation of the properties of this acid, we are indebted chiefly to Scheele and Priestly.

1. It may be obtained by putting a quantity of the spar in powder into a retort, pouring over it an equal

quantity of sulphuric acid, and then applying a very gentle heat. A gas issues from the beak of the retort, which may be received in the usual manner in glass jars standing over mercury. This gas is fluoric acid.

The acid may be obtained dissolved in water by luting to the retort a receiver containing water. The distillation is to be conducted with a very moderate heat, not only to allow the gas to condense, but also to prevent the fluor itself from subliming. After the process, provided a glass retort has been employed, a crust of white earth is found in the receiver, which has all the properties of silica.

Scheele supposed that the silica produced was formed of fluoric acid and water; and Bergman adopted the same opinion. But Wiegleb and Buccholz showed that the quantity of silica was exactly equal to what the retort lost in weight; and Meyer completed the proof that it was derived from the glass, by the following experiment. He put into each of three equal cylindrical tin vessels a mixture of three ounces of sulphuric acid and one ounce of fluor, which had been pulverized in a mortar of metal. Into the first he put one ounce of pounded glass; into the second the same quantity of quartz in powder; and into the third nothing. Above each of the vessels he hung a spunge moistened with water, and having covered them, he exposed them to a moderate heat. The sponge in the first cylinder was covered with the crust in half an hour; the sponge in the second in two hours; but no crust was formed in the third, though it was exposed several days. In consequence of this decisive experiment, Bergman gave up his opinion; and wrote an account of Meyer's experiment to Morveau, who was employed in translating his works, to enable him to correct the mistake in his notes.

Soon after the discovery of this acid, difficulties and doubts concerning its existence as a peculiar acid were started by some French chemists. To remove these objections, Mr. Scheele instituted and published a new set of experiments; which not only completely established the peculiar nature of the fluoric acid, but once more displayed the unrivalled abilities of the illustrious discoverer. It would be needless to enumerate these objections, as they originated entirely from want of precision, and did not produce a single convert.

2. Fluoric acid gas is invisible and elastic like air; it does not maintain combustion, nor can animals breathe it without death. It has a pungent smell, not unlike that of muriatic acid. It is heavier than common air. It corrodes the skin almost instantly.

3. Neither caloric nor light produces any alteration on it.

4. When water is admitted in contact with this gas, it absorbs it rapidly; and if the gas has been obtained by means of glass vessels, it deposits at the same time a quantity of silica.

Water absorbs a considerable proportion of this gas, but the precise quantity has not been determined. The compound is usually termed fluoric acid by chemists. It is specifically heavier than water, has an acid taste, reddens vegetable blues, and does not freeze till cooled down to 23°. When heated, the acid gas is easily expelled, except the last portions of it, which adhere with great obstinacy.

5. Neither oxygen gas nor any of the simple combustibles or incombustibles produce any change on fluoric acid, either in the gaseous or liquid state.

6. Fluoric acid gas does not act upon any of the metals, but liquid fluoric acid is capable of oxidizing iron, zinc, copper, and arsenic. It does not act upon gold, platinum, silver, mercury, lead, tin, antimony, cobalt.

7. It combines with alkalies, earths, and metallic oxides, and forms with them salts which are denominated fluats. See FLUAT.

The most singular property of fluoric acid is the facility with which it corrodes glass and siliceous bodies, especially when hot, and the ease with which it holds silica in solution even when in the state of gas. This affinity for silica is so great, that the thickest glass vessels can only withstand its action for a short time; and the greatest precautions are scarcely sufficient to obtain it entirely free from siliceous earth.

8. It produces no change, as far as is known, upon any of the acids already described.

9. Its affinities are as follows:

Lime,
Barytes,
Strontian,
Magnesia,
Potass,
Soda,
Ammonia,
Glucina,
Alumina,
Zirconia,
Silica.

10. As fluoric acid produces an insoluble compound with lime, it may be employed with great advantage, as Pelletier has observed, to detect the presence of that earth when held in solution. A drop or two of the acid causes a milky cloud or precipitate to appear, if any lime is present. The property which this acid has of corroding glass, has induced several ingenious men to attempt, by means of it, to engrave, or rather etch, upon glass. The glass is covered completely with wax; and then that part where the letters or figures are to appear is laid bare, by removing the wax. The whole is then exposed for some time to the hot vapours of fluoric acid. This simple process is employed with advantage in writing labels on glass vessels, and in graduating thermometers, and other similar instruments. The discovery is by no means new; it has been shewn by Beckman and Accum, that this acid was employed for that purpose by Henry Swanhard, an artist of Nuremberg, as early as 1670. He seems to have kept his art for some time secret, but the receipt was made public by Pauli in 1725. See ETCHING ON GLASS.

FLUSTRA, a genus of insects of the order zoophyta; an animal of the polypus kind, proceeding from porous shells; stem fixed, foliaceous, membranaceous, consisting of numerous rows of cells united together, and woven like a mat. There are many species. The verticillata is found in the Mediterranean, adhering to fuci: the cells, when magnified, appear surrounded by sharp denticles, with a long bristle in the front of each, bending inwards like a horn; the mouths incline forwards, and their whole substance appears full of small points.

FLUTE, *fistula*, an instrument of music, the simplest of all those of the wind kind. It is played on by blowing it with the mouth, and the tones or notes are changed by stopping and opening the holes disposed for that purpose along its side. The ancient fistulæ, or flutes, were made of rods, afterwards of wood, and last of metal; but how they were blown, whether as our flutes, or as hautboys, does not appear.

Flute, *German*, is an instrument entirely different from the common flute. It is not, like that, put into the mouth to be played, but the end is topt with a tampion, or plug, and the lower lip is applied to a hole about two inches and a half, or three inches, distant from the end. This instrument is usually about a foot and a half long, rather larger at the upper end than the lower, and perforated with holes, besides that for the mouth, the lowest of which is stopt and opened by the little finger's pressing on a brass, or sometimes a silver key, like those in hautboys, bassoons, &c. It is found exceeding sweet and agreeable, and serves as a treble in a concert.

Flute, or Fluyt, (originally perhaps float) is a kind of long vessel, with flat ribs, or floor timbers; round behind, and swelled in the middle; serving chiefly for the carrying of provisions in fleets, or squadrons of ships, though it is also used for merchandize.

Flutes, or Flutings, in architecture, perpendicular channels, or cavities, cut along the shaft of a column, or pilaster. See Architecture.

FLUX, in medicine, an extraordinary issue, or evacuation, of some humours of the body. See Medicine.

Flux, in metallurgy, is sometimes used synonymously with fusion: for instance, an ore, or rather matter, is said to be in liquid flux, when it is completely fused. But the word flux is generally used to signify certain saline matters, which facilitate the fusion of ores, and other substances which are difficultly fusible in assays, and in the reductions of ores. We shall here describe the fluxes recommended by Bergman, in vol. ii.

1. The phosphoric acid, or rather the microcosmic salt, as it is called, which contains that acid partly saturated with mineral, partly with ammonia, and loaded besides with much water. This salt, when exposed to the flame, boils and foams violently, with a continual crackling noise, until the water and ammonia have flown off; afterwards it is less agitated, sending forth something like black scoriæ arising from the burned gelatinous part: these, however, are soon dispelled, and exhibit a pellucid sphericle encompassed by a beautiful green cloud, which is occasioned by the deflagration of the phosphorus, arising from the extrication of the acid by means of the inflammable matter. The clear globule which remains, upon the removal of the flame, continues longer soft than that formed by borax, and therefore is more fit for the addition of the matter to be dissolved. The ammonia is expelled by the fire; therefore an excess of acid remains in what is left behind, which readily attracts moisture in a cool place. 2. Soda, when put upon charcoal, melts superficially, penetrates the charcoal with a crackling noise, and then disappears. In the spoon it yields a permanent and pullucid sphericle, as long as it is kept fluid by the blue apex of the flame; but when the heat is diminished, it becomes opaque, and assumes a milky colour. It attacks several earthy matters, particularly those of the siliceous kind, but cannot be employed on charcoal. 3. Crystallized borax, exposed to the flame urged by the blow-pipe or charcoal, first becomes opaque, white, and excessively swelled, with various protuberances, or branches proceeding out from it. When the water is expelled, it easily collects itself into a mass, which, when well fused, yields a transparent sphericle, retaining its transparency even after cooling. If calcined borax is employed, the clear sphericle is obtained the sooner.

Having provided every thing necessary, the following directions are next to be attended to. 1. A common tallow candle, not too thick, is generally preferable to a wax candle, or to a lamp. The snuff must not be cut too short, as the wick should bend towards the object. 2. The weaker exterior flame must first be directed upon the object, until its effects are discovered; after which the interior flame must be applied. 3. We must observe with attention whether the matter decrepitates, splits, swells, vegetates, boils, &c. 4. The piece exposed to the flame should scarcely ever exceed the size of a peppercorn, but ought always to be large enough to be taken up by the forceps. 5. A small piece should be added separately to each of the fluxes; concerning which it must be observed whether it dissolves wholly or only in part; whether this is effected with or without effervescence, quickly or slowly; whether the mass is divided into a powder, or gradually and externally corroded; with what colour the glass is tinged, and whether it becomes opaque, or remains pellucid.

Having given these directions, Mr. Bergman proceeds next to consider the subjects proper to be examined by the blowpipe. These he divides into four classes: 1. Saline; 2. Earthy; 3. Inflammable; and 4. Metallic. As the subject, however, is treated at considerable length, we shall refer the reader to Mr. Bergman's writings, and confine ourselves in this place to what he has advanced concerning the last of these subjects, namely, metallic substances.

The perfect metals, when calcined (oxygenated) in the moist way, recover their former nature by simple fusion. The imperfect metals are calcined by fire, especially by the exterior flame; and then, in order to their being reduced, indispensably require the contact of an inflammable substance. With respect to fusibility, the two extremes are mercury and platina; the former being scarcely ever seen in a solid form, and the latter almost as difficult of fusion. The metals, therefore, may be ranked in this order, according to their degrees of fusibility. 1. Mercury; 2. Tin; 3. Bismuth; 4. Lead; 5. Zinc; 6. Antimony; 7. Silver; 8. Gold; 9. Arsenic; 10. Cobalt; 11. Nickel; 12. Iron; 13. Manganese; 14. Platinum. The last two do not yield to the blowpipe, and indeed forged iron does not melt without difficulty; but cast iron perfectly.

Metals in fusion affect a globular form, and easily roll off the charcoal, especially when of the size of a grain of pepper. Either smaller pieces, therefore, ought to be used, or they should rest in hollows made in the charcoal. On their first melting they assume a polished surface, an appearance always retained by the perfect metals; but the imperfect are soon obscured by a pellicle formed of the calx (oxide) of the metal. The colours

communicated by the calces vary, according to the nature of the metal from which the calx is produced. Some of the calces easily recover their metallic form by simple exposure to flame upon the charcoal; others are reduced in this way with more difficulty; and some not at all. The reduced calces of the volatile metals immediately fly off from the charcoal. In the spoon they exhibit globules; but it is very difficult to prevent them from being first dissipated by the blast.

The metals are taken up by the fluxes; but as soda yields an opaque spherule, it is not to be made use of. Globules of borax dissolve and melt any metallic calx; and, unless too much loaded with it, appear pellucid and coloured. A piece of metal calcined in flux produces the same effect, but more slowly. A portion of the calx generally recovers its metallic form, and floats on the melted matter like one or more excrescences.

The calces of the perfect metals are reduced by borax in the spoon, and adhere to it at the point of contact, and there only. The microcosmic salt acts like borax, but does not reduce the metals. It attacks them more powerfully on account of its acid nature; at the same time it preserves the spherical form, and therefore is adapted in a peculiar manner to the investigation of metals.

The tinge communicated to the flux frequently varies, being different in the fused and in the cooled globule; for some of the dissolved calces, while fused, show no colour, but acquire one while cooling; but others, on the contrary, have a much more intense colour while in the state of fluidity. Should the transparency be injured by too great a concentration of colour, the globule, on compressing it with the forceps, or drawing it out into a thread, will exhibit a thin and transparent mass; but if the opacity arises from supersaturation, more flux must be added; and as the fluxes attract the metals with unequal forces, the latter precipitate one another.

Metals when mineralized by acids have the properties of metallic salts; when mineralized by carbonic acid, they possess the properties of calces, that volatile substance being easily expelled without any effervescence; but when combined with sulphur they possess properties of a peculiar kind. They may then be melted, or even calcined upon the charcoal, as also in a golden or silver spoon. The volatile parts are distinguished by the smell or smoke; the fixed residua, by the particles reduced or precipitated upon iron, or from the tinge of the fluxes.

Gold in its metallic state fuses on the charcoal, and is the only metal which remains unchanged. It may be oxygenated in the moist way by solution in aqua regia; but to calcine it also by fire, we must pursue the following method: To a globule of microcosmic salt, let there be added a small piece of solid gold, of gold leaf, purple mineral, or, which is best of all, of the crystalline salt formed by a solution of gold in aqua regia containing sea-salt. Let this again be melted, and added while yet soft to turbith mineral, which will immediately grow red on the contact. The fusion being afterwards repeated, a vehement effervescence arises; and when this is considerably diminished, let the blast be stopped for a few moments, again begun, and so continued until almost all the bubbles disappear. After this the spherule, on cooling, assumes a ruby colour; but if this does not happen, let it be just made soft by the exterior flame, and upon hardening, this tinge generally appears. Should the process fail at first, owing to some minute circumstances which cannot be described. it will succeed on the second or third trial. The ruby-coloured globule, when compressed by the forceps while hot, frequently becomes blue; by sudden fusion it generally assumes an opal colour, which by refraction appears blue, and by reflection of a brown red. If further urged by the fire it loses all colour, and appears like water; but the redness may be reprod ced several times by the addition of turbith mineral. The flux is reddened in the same manner by the addition of tin instead of turbith; but it has a yellowish hue, and more easily becomes opaque; while the redness communicated by turbith mineral has a purple tinge, and quite resembles a ruby. Borax produces the same phenomena, but more rarely; and in all cases the slightest variation in the management of the fire will make the experiment fail entirely.

The ruby colour may also be produced by copper; whence a doubt may arise, whether it is the gold or the remains of the copper that produce this effect. Mr. Bergman thinks it probable that both may contribute towards it, especially as copper is often found to contain gold.

This precious metal cannot directly be mineralized by sulphur; but by the medium of iron is sometimes formed into a golden pyrites. Here, however, the quantity of gold is so small, that a globule cannot scarcely be extracted from it by the blowpipe.

Grains of native platinum are not affected by the blowpipe, either alone or mixed with fluxes; which, however, are frequently tinged green by it: but platinum, precipitated from aqua regia by vegetable or volatile alkali, is reduced by microcosmic salt to a small malleable globule. Our author has been able to unite seven or eight of these into a malleable mass; but more of them produced only a brittle one. Platinum scarcely loses all its iron, unless reduced to very thin fusion.

Silver in its metallic state easily melts, and resists calcination. Silver leaf fastened by means of the breath, or a solution of borax, may easily be fixed on it by the flame, and through the glass it appears of a gold colour; but care must be taken not to crack the glass. Calcined silver precipitated from nitrous acid by fixed alkali is easily reduced. The microscomic acid dissolves it speedily and copiously; but on cooling it becomes opaque, and of a whitish yellow, which is also sometimes the case with leaf-silver. Copper is discovered by a green colour, and sometimes by that of a ruby, unless we choose rather to impute that to gold. The globules can scarcely be obtained pellucid, unless the quantity of calx is very small; but a longer fusion is necessary to produce an opacity with borax. The globule, loaded with dissolved silver during the time of its fusion in the spoon, covers a piece of copper with silver, and becomes itself of a pellucid green: antimony quickly takes away the milky opacity of dissolved luna cornea, and separates the silver in distinct grains. Cobalt, and most of the other metals likewise, precipitate silver on the same principles as in the moist way, viz. by a double elective attraction. This metal, when mineralized by marine and vitriolic acids, yields a natural luna cornea, which produces a number of small metallic globules on the charcoal: it dissolves in

microcosmic salt, and renders it opaque, and is reduced, partially at least, by borax. Sulphurated silver, called also the glassy ore of that metal, fused upon charcoal, easily parts with the sulphur it contains; so that a polished globule is often produced, which, if necessary, may be depurated by borax. The silver may also be precipitated by the addition of copper, iron, or manganese. When arsenic makes part of the compound, as in the red ore of arsenic, it must first be freed from the sulphur by gentle roasting, and finally entirely depurated by borax. It decrepitates in the fire at first.

Copper, together with sulphur and arsenic mixed with silver, called the white ore of silver, yields a regulus having the same alloy.

Galena, which is an ore of lead containing sulphur and silver, is to be freed in the same manner from the sulphur; after which the lead is gradually dissipated by alternately melting and cooling, or is separated in a cupel from the galena by means of the flame. Bergman has not been able to precipitate the silver distinct from the lead, but the whole mass becomes malleable; and the same is true of tin, but the mass becomes more brittle.

Pure mercury flies off from the charcoal with a moderate heat, the fixed heterogeneous matters remaining behind. When calcined, it is easily reduced and dissipated, and the fluxes take it up with effervescence; but it is soon totally driven off. When mineralized by sulphur, it liquefies upon the charcoal, burns with a blue flame, smokes, and gradually disappears; but, on exposing cinnabar to the fire on a polished piece of copper, the mercurial globules are fixed upon it all round.

Lead in its metallic state readily melts, and continues to retain a metallic splendour for some time. By a more intense heat it boils and smokes, forming a yellow circle upon the charcoal. It communicates a yellow colour, scarcely visible, to the fluxes; and when the quantity is large, the globule, on cooling, contracts more or less of a white opacity. It is not precipitated by copper when dissòlved; nor do the metals precipitate it from sulphur in the same order as from the acids. When united to carbonic acid, it grows red on the first touch of the flame; when the heat is increased it melts, and is reduced to a multitude of small globules. When united with phosphoric acid it melts, and yields an opaque globule, but is not reduced. With fluxes it shows the same appearances as oxide of lead. When mineralized by sulphur, lead easily liquefies, and being gradually deprived of the volatile part, yields a distinct regulus, unless too much loaded with iron. It may be precipitated by iron and copper.

A small piece of copper, either solid or foliated, sometimes communicates a ruby colour to fluxes, especially when assisted by tin or turbith mineral. If the copper is a little more or further calcined, it produces a green pellucid globule, the tinge of which grows weaker by cooling, and even verges towards a blue. By long fusion with borax, the colour is totally destroyed upon charcoal, but scarcely in the spoon. When once destroyed, this colour can scarcely be reproduced by nitre; but it remains fixed with microcosmic salt. If the calx or metal to be calcined is added in considerable quantity during fusion, it acquires an opaque red on cooling, though it appears green while pellucid and fused; but by a still larger quantity it contracts an opacity even while in fusion, and upon cooling a metallic splendour. Even when the quantity of copper is so small as scarcely to tinge the flux, a visible pellicle is precipitated upon a piece of polished iron added to it during strong fusion, and the globule in its turn takes the colour of polished iron; and in this way the smallest portions of copper may be discovered. The globule made green by copper, when fused in the spoon with a small portion of tin, yields a spherule of the latter mixed with copper, very hard and brittle: in this case the precipitated metal pervades the whole of the mass, and does not adhere to the surface. Cobalt precipitates the calx of copper dissolved in the spoon by a flux, in a metallic form, and imparts its own colour to glass, which nickel cannot do. Zinc also precipitates it separately, and rarely upon its own surface, as we can scarcely avoid melting it. When mineralized by the carbonic acid, copper grows black on the first contact of the flame, and melts in the spoon; on the charcoal the lower part, which touches the support, is reduced. With a superabundance of marine acid, it tinges the flame of a beautiful colour: but with a small quantity shows no appearance of the metal in that way. Thus the beautiful crystals of Saxony, which are cubic, and of a deep green, do not tinge the flame, though they impart a pellucid greenness to microcosmic salt. An opaque redness is easily obtained with borax: but Mr. Bergman could not produce this colour with microcosmic salt. Copper simply sulphurated, when cautiously and gently roasted by the exterior flame, yields at last by fusion a regulus surrounded with a sulphurated crust. The mass roasted with borax separates the regulus more quickly.

If a small quantity of iron happens to be present, the piece to be examined must first be roasted, after which it must be dissolved in borax, and tin added to precipitate the copper. The regulus may also be obtained by sufficient calcination and fusion, even without any precipitant, unless the ore is very poor. When the pyrites contain copper, even in the quantity of the one-hundredth part of their weight, its presence may be detected by these experiments. Let a grain of pyrites, of the size of a flax-seed, be roasted, but not so much as to expel all the sulphur; let it then be dissolved by borax, a polished rod of iron added, and the fusion continued until the surface when cooled loses all splendour. As much borax is required as will make the whole of the size of a grain of hemp-seed. Slow fusion is injurious, and the precipitation is also retarded by too great tenuity; but this may be corrected by the addition of a little lime. Too much calcination is also inconvenient; for by this the globule forms slowly, is somewhat spread, becomes knotty when warm, corrodes the charcoal, destroys the iron, and the copper does not precipitate distinctly. This defect is corrected by a small portion of crude ore. When the globule is properly melted, according to the directions already given, it ought to be thrown into cold water immediately on stopping the blast, in order to break it suddenly. If the copper contained in it is less than one-hundredth part, one end of the wire only has a cupreous appearance, but otherwise the whole.

Dr. Gahn has another method of examining the ores of copper, namely, by exposing a grain of the ore, well freed from sulphur by calcination, to the action of the

flame driven suddenly upon it by intervals. At those instances a cupreous splendour appears on the surface, which otherwise is black; and this splendour is more quickly produced in proportion as the ore is poorer. The flame is tinged green by cupreous pyrites on roasting.

Forged iron is calcined, but can scarcely be melted. It cannot be melted by borax, though it may by microcosmic salt, and then it becomes brittle. Calcined iron becomes magnetic by being heated on the charcoal, but melts in the spoon. The fluxes become green by this metal; but in proportion as the oxygen is more abundant, they grow more of a brownish yellow. On cooling, the tinge is much weakened, and when originally weak, vanishes entirely. By too much saturation the globule becomes black and opaque. The sulphureous pyrites may be collected into a globule by fusion, and is first surrounded by a blue flame; but as the metal is easily calcined, and changes into black scoriæ, neither by itself nor with fluxes does it exhibit a regulus. It grows red on roasting.

Tin easily melts before the blowpipe, and is calcined. The fluxes dissolve the calx sparingly; and when saturated, contract a milky opacity. Some small particles of this metal dissolved in any flux may be distinctly precipitated upon iron. Crystallized ore of tin, urged by fire upon the charcoal, yields its metal in a reguline state.

Bismuth presents nearly the same appearances as lead; the calx is reduced on the coal, and fused in the spoon. The calx, dissolved in microcosmic salt, yields a brownish yellow globule, which grows more pale upon cooling, at the same time losing some of its transparency. Too much calx renders the matter perfectly opaque. Borax produces a similar mass in the spoon, but on the coal a grey one, which can scarcely be freed from bubbles. On fusion the glass smokes, and forms a cloud about it. Bismuth is easily precipitated by copper and iron. Sulphurated bismuth is easily fused, exhibiting a blue flame and sulphureous smell. Cabalt, when added, by means of sulphur, enters the globule; but the scoria soon swells into distinct partitions; which, when further urged by fire, throw out globules of bismuth. Sulphurated bismuth, by the addition of borax, may be distinctly precipitated by iron or manganese.

Regulus of nickel when melted is calcined, but more slowly than other metals. The calx imparts an hyacinthine colour to fluxes, which grows yellow on cooling, and by long continued fire may be destroyed. If the calx of nickel is contaminated by ochre of iron, the latter is first dissolved. Nickel dissolved is precipitated on iron, or even on copper; an evident proof that it does not originate from either of these metals. Sulphurated nickel is no where found without iron and arsenic: the regulus is obtained by roasting, and fusing with borax, though it still remains mixed with some other metals.

Regulus of arsenic takes fire by a sudden heat, and not only deposits a white smoke on charcoal, but diffuses the same all around. The calx smokes with a smell of garlic, but does not burn. The fluxes grow yellow, without growing opaque, on adding a proper quantity of calx, which is dispelled by a long continuance of the heat. This semimetal is precipitated in a metallic form by iron and copper, but not by gold. Yellow arsenic liquefies, smokes, and totally evaporates: when heated by the external flame, so as neither to liquefy nor smoke, it grows red, and yellow again upon cooling. When it only begins to melt, it acquires a red colour, which remains after cooling. Realgar liquefies more easily, and is besides totally dissipated.

Regulus of cobalt melts, and may partly be depurated by borax, as the iron is first calcined and taken up. The smallest portion of the calx tinges the flux of a deep-blue colour, which appears of a violet by refraction, and this colour is very fixed in the fire. Cobalt is precipitated upon iron from the blue globule, but not upon copper. When calx of iron is mixed with that of cobalt in a flux, the former is dissolved. This semimetal take up about one-third of its weight of sulphur in fusion, after which it can hardly be melted again. It is precipitated by iron, copper, and several other metals. The common ore yields an impure regulus by roasting. The green cobalt, examined by our author, tinges the microcosmic salt blue; but at the same time shows red spots, indicating copper.

Zinc exposed to the blowpipe melts, takes fire, sending forth a beautiful blueish-green flame, which however is soon extinguished by a lanuginous calx; but if the reguline nucleus included in this lanuginous matter (commonly called flowers of zinc) is urged by the flame, it will be now and then inflamed, and as it were, explode and fly about. With borax it froths, and at first tinges the flame. It continually diminishes, and the flux spreads upon the charcoal; but in used microcosmic salt, it not only froths, but sends forth flashes with a crackling noise. Too great heat makes it explode with the emission of ignited particles. The white calx, or flower, exposed to the flame on charcoal, becomes yellowish, and has a kind of splendour which vanishes when the flame ceases. It remains fixed, and cannot be melted. The fluxes are scarcely tinged, but when saturated by fusion, they grow opaque and white on cooling. Clouds are formed around the globules, of a nature similar to those of the metallic calx. Dissolved zinc is not precipitated by any other metal. When mineralized by carbonic acid gas, it has the same properties as calcined zinc. In the pseudo galena sulphur and iron are present. These generally, on the charcoal, smell of sulphur, melt, and tinge the flame more or less, depositing a cloud all around. Those which have no matrix are tinged by those which contain iron, and acquire by saturation a white opaque colour, verging to brown or black, according to the variety of composition.

Regulus of antimony, fused and ignited on the charcoal, affords a beautiful object; for if the blast of air be suddenly stopped, a thick white smoke rises perpendicularly, while the lower part round the globule is condensed into crystalline spiculæ, similar to those called argentine flowers. The calx tinges fluxes of an hyacinthine colour; but on fusion smokes, and is easily dissipated, especially on the charcoal, though it also deposits a cloud on it. The dissolved metal may be precipitated by iron and copper, but not by gold. Crude antimony liquefies on the charcoal, spreads, smokes, penetrates it, and at last disappears entirely, except a ring which it leaves behind.

Regulus of manganese scarcely yields to the flame. The black calx tinges the fluxes of a blueish colour; bo-

rax, unless saturated, communicates more of a yellow colour. The colour may be gradually dissolved altogether by the interior flame, and again reproduced by a small particle of nitre, or the exterior flame alone. Combined with carbonic acid, it is of a white colour, which changes by ignitition to black. In other respects it shows the same experiments as the black calx.

Fixed alkalis, nitre, borax, tartar, and common salt, are the saline matters of which fluxes are generally composed. But the word flux is more particularly applied to mixtures of different proportions of only nitre and tartar; and these fluxes are called by particular names, according to the proportions of these ingredients, as in the following instances.

Flux, *white*, is made with equal parts of nitre and of tartar detonated together, by which they are alkalised. The residuum of this detonation is an alkali composed of alkalis of the nitre and of the tartar, both which are absolutely of the same nature. As the proportion of nitre in this mixture is more than is sufficient to consume entirely all the inflammable matter of the tartar, the alkali remaining after the detonation is perfectly white, and is therefore called white flux; and as this alkali is made very quickly, it is also called extemporaneous alkali. When a small quantity only of white flux is made, as a few ounces for instance, some nitre always remains undecomposed, and a little of the acid of the tartar, which gives a red, or even a black colour, to some part of the flux; but this does not happen when a large quantity of white flux is made, because then the heat is much greater. The small quantity of undecomposed nitre and tartar which remains in white flux is not hurtful in most of the metallic fusions in which this flux is employed; but if the flux is required perfectly pure, it might easily be disengaged from those extraneous matters by a long and strong calcination, without fusion.

Flux, *crude*. By crude flux is meant the mixture of nitre and tartar in any proportions, without detonation. Thus the mixture of equal parts of the two salts used in the preparation of the white flux, or the mixture of one part of nitre and two parts of tartar for the preparation of the black flux, are each of them a crude flux before detonation. It has also been called white flux, from its colour; but this might occasion it to be confounded with the white flux above described. The name, therefore, of crude flux is more convenient. Crude flux is detonated and alkalised during the reductions and fusions in which it is employed; and is then changed into white or black flux, according to the proportions of which it is composed. This detonation produces good effects in these fusions and reductions, if the swelling and extravasation of the detonating matters are guarded against. Accordingly, crude flux may be employed successfully in many operations; as, for instance, in the ordinary operation for procuring the regulus of antimony.

Flux, *black*. Black flux is produced from the mixture of two parts of tartar and one part of nitre detonated together. As the quantity of nitre which enters into the composition of this flux is not sufficient to consume all the inflammable matter of the tartar, the alkali which remains after the detonation contains much black matter, of the nature of coal, and is therefore called black flux. This flux is designedly so prepared, that it shall contain a certain quantity of inflammable matter; for it is thereby capable, not only of facilitating the fusion of metallic earths like the white flux, but also of reviving these metals. From this property it is also called reducing flux; the black flux, therefore, or crude flux made with such proportions of the ingredients as to be convertible into black flux, ought always to be used when considered as metallic matters are at once to be fused and reduced. See Fusion.

FLUXION, in mathematics, denotes the velocity by which the fluents or flowing quantities, increase or decrease; and may be positive or negative, according as it relates to an increment or decrement.

The doctrine of fluxions, first invented by sir Isaac Newton, is of great use in the investigation of curves, and in the discovery of the quadratures of curvilinear spaces, and their rectifications. In this method, magnitudes are conceived to be generated by motion, and the velocity of the generating motion is the fluxion of the magnitude. Thus, the velocity of the point that describes a line, is its fluxion, and measures its increase or decrease. When the motion of this point is uniform, its fluxion or velocity is constant, and may be measured by the space described in a given time. But when the motion varies, the fluxion or velocity at any given point is measured by the space that would be described in a given time, if the motion was to be continued uniformly from that term.

Thus let the point m be conceived to move from A,

A ———————— m ———————— m .... r
R

and generate the variable right line Am, by a motion any how regulated; and let its velocity, when it arrives at any proposed position or point R, be such as would, was it to continue uniform from that point, be sufficient to describe the line Rr, in the given time allotted for the fluxion, then will Rr be the fluxion of the variable line Am, in the term or point R. The fluxion of a plain surface is conceived in like manner, by supposing a given right line $m\,n$ (plate LXIV. Miscel. fig. 89) to move parallel to itself, in the plane of the parallel and immoveable lines AF and BG; for if, as above, Rr be taken to express the fluxion of the line Am, and the rectangle RrsS be completed: then that rectangle, being the space which would be uniformly described by the generating line mn, in the time that Am would be uniformly increased by mr, is therefore the fluxion of the generated rectangle Bm, in that position. If the length of the generating line mn continually varies, the fluxion of the area will still be expounded by a rectangle under that line, and the fluxion of the abciss or base; for let the curvilinear space Anm (fig. 90) be generated by the continual and parallel motion of the variable line mn; and let Rr be the fluxion of the base or absciss Am, as before; then the rectangle RrsS, will be the fluxion of the generated space Amn. Because, if the length and velocity of the generating line mn were to continue invariable from the position RS, the rectangle RrsS would then be uniformly generated with the very velocity wherewith it begins to be generated, or with which the space Amn is increased in that position.

Fluxions, *Notation of.* Invariable quantities, or those which neither increase or decrease, are represented by the first letters of the alphabet, as a, b, c, d, &c.

and the variable or flowing quantities by the last letters, as v, w, x, y, z; thus, the diameter of a given circle may be denoted by a; and the sine of any arch thereof, considered as variable, by x. The fluxion of a quantity represented by a single letter, is expressed by the same letter with a dot or full point over it: thus, the fluxion of x is represented by $\dot{x}$, and that of y by $\dot{y}$. And, because these fluxions are themselves often variable quantities, the velocities with which they either increase or decrease, are the fluxions of the former fluxions, which may be called second fluxions, and are denoted by the same letters with two dots over them, as $\ddot{x}$, $\ddot{y}$. In the same manner the fluxions of second fluxions are called third fluxions, and denoted by the same letters with three dots over them, as $\dddot{x}$, $\dddot{y}$; and so on for fourth, fifth, &c. fluxions.

The whole doctrine of fluxions consists in solving the two following problems, viz. 1. From the fluent, or variable flowing quantity given, to find the fluxion; which constitute what is called the direct method of fluxions. 2. From the fluxion given, to find the fluent, or flowing quantity; which makes the inverse method of fluxions.

Direct Method of Fluxions.—The doctrine of this part of fluxions is comprized in these rules:

1. To find the fluxion of any simple variable quantity, the rule is to place a dot over it: thus, the fluxion of x is $\dot{x}$, and of y, $\dot{y}$. Again, the fluxion of the compound quantity $x+y$, is $\dot{x}+\dot{y}$; also the fluxion of $x-y$, is $\dot{x}-\dot{y}$.

2. To find the fluxion of any given power of a variable quantity, multiply the fluxion of the root by the exponent of the power, and the product by that power of the same root, whose exponent is less by unity than the given exponent. This rule is expressed more briefly, in algebraical character, by $nx^{n-1}\dot{x}$ = the fluxion of x^n. Thus, the fluxion of x^3 is $\dot{x} \times 3 \times x^2 = 3x^2\dot{x}$; and the fluxion of x^5 is $\dot{x} \times 5 \times x^4 = 5x^4\dot{x}$. In the same manner the fluxion of $\overline{a+y}|^7$ is $7\dot{y} \times \overline{a+y}^6$; for the quantity a being constant, $\dot{y}$ is the true fluxion of the root $a+y$. Again, the fluxion of $a^2+z^2\ ^{\frac{3}{2}}$ will be $\frac{3}{2} \times 2z\dot{z} \times \overline{a^2+z^2}|^{\frac{1}{2}}$: for here, x being put $= a^2+z^2$, we have $\dot{x} = 2z\dot{z}$; and therefore $\frac{3}{2}x^{\frac{1}{2}}\dot{x}$, for the fluxion of $x^{\frac{3}{2}}$ (or $a^2+z^2\ ^{\frac{3}{2}}$) is $= 3z\dot{z}\sqrt{a^2+z^2}$.

3. To find the fluxion of the product of several variable quantities, multiply the fluxion of each, by the product of the rest of the quantities; and the sum of the products, thus arising, will be the fluxion sought. Thus, the fluxion of xy is $\dot{x}y + \dot{y}x$; that of xyz, is $\dot{x}yz + \dot{y}xz + \dot{z}xy$; and that of $vxyz$, is $\dot{v}xyz + \dot{x}vyz + \dot{y}vxz + \dot{z}vxy$. Again, the fluxion of $x + x \times b - y = ab + bx - ay - xy$, is $b\dot{x} - a\dot{y} - \dot{x}y - \dot{y}x$.

4. To find the fluxion of a fraction, the rule is, from the fluxion of the numerator multiplied by the denominator, subtract the fluxion of the denominator multiplied by the numerator, and divide the remainder by the square of the denominator. Thus the fluxion of $\frac{x}{y}$, is $\frac{y\dot{x} - x\dot{y}}{y^2}$; that of $\frac{x}{x+y}$, is $\frac{\dot{x} \times \overline{x+y} - \overline{\dot{x}+\dot{y}} \times x}{\overline{x+y}|^2} = \frac{y\dot{x} - x\dot{y}}{\overline{x+y}|^2}$; and that of $\frac{x+y+z}{x+y}$, or $1 + \frac{z}{x+y}$, is $\frac{\dot{z} \times \overline{x+y} - \overline{\dot{x}+\dot{y}} \times z}{\overline{x+y}|^2}$; and so of others.

In the examples hitherto given, each is resolved by its own particular rule: but in those that follow, the use of two or more of the above rules is requisite: thus (by rules 2. and 3.) the fluxion of x^2y^2 is found to be $2x^2y\dot{y} + 2y^2x\dot{x}$; that of $\frac{x^2}{y^2}$, is found (by rules 2. and 4.) to be $\frac{2y^2x\dot{x} - 2x^2y\dot{y}}{y^4}$; and that of $\frac{x^2y^2}{z}$, is (by rules 2. 3. and 4.) found to be $\frac{\overline{2x^2y\dot{y} + 2y^2x\dot{x}} \times z - x^2y^2\dot{z}}{z^2}$.

5. When the proposed quantity is affected by a co-efficient, or constant multiplicator, the fluxion found as above must be multiplied by that co-efficient or multiplicator: thus, the fluxion of $5x^3$, is $15x^2\dot{x}$; for the fluxion of x^3 is $3x^2\dot{x}$, which, multiplied by 5, gives $15x^2\dot{x}$. And, in the very same manner, the fluxion of ax^n will be $nax^{n-1}\dot{x}$.

Having thus explained the manner of determining the first fluxions of variable quantities, it remains to say something of second, third, &c. fluxions. We have already observed, that the second fluxion of a quantity is the fluxion of the first fluxion; and by the third fluxion is meant the fluxion of the second; the fourth, of the third, and so on. The fluxions, therefore, of every order, are only the measures of the velocities by which their respective flowing quantities, viz. the fluxions of the immediately preceding order, are generated. Hence it appears, that a second fluxion always shows the rate of the increase or decrease of the first fluxion; and that the third, fourth, &c. the fluxions differ in nothing, except their order and notation, from first fluxions; and therefore, are also determinable in the very same manner, by the rules already laid down: thus (by rule 4.) the (first) fluxion of x^3 is $3x^2\dot{x}$; and if $\dot{x}$ is supposed constant, that is, if the root x be generated with an equable or uniform velocity, the fluxion of $3x^2\dot{x}$ (or $3\dot{x} \times x^2$) again taken (by the same rule) will be $3\dot{x} \times 2x\dot{x}$, or $6x\dot{x}^2$; which, therefore, is the second fluxion of x^3. Again, the third fluxion of x^3, or the fluxion of $6x\dot{x}^2$, is found to be $6\dot{x}^3$; further than which we cannot go in this case, because the last fluxion, $6\dot{x}^3$, is here a constant quantity.

In the preceding example, the root x is supposed to be generated with an equable velocity: but if the velocity be an increasing or decreasing one, then $\dot{x}$, expressing the measure thereof, being variable, will also have its fluxion, which is denoted, as said above, by $\ddot{x}$; and the fluxion of $\ddot{x}$ by $\dddot{x}$, and so on with respect to the higher orders.

Here follow some examples, in which the root x (or y) is supposed to be generated with a variable velocity. Thus, the fluxion of x^3 being $3x^2\dot{x}$ (or $3x^2 \times \dot{x}$), the fluxion of $3x^2 \times \dot{x}$, considered as a rectangle, will (by rule 3.) be found to be $6x\dot{x} \times \dot{x} + 3x^2 \times \ddot{x} = 6x\dot{x}^2 + 3x^2\ddot{x}$; which is the second fluxion of x^3. Moreover, from the fluxion last found, we shall in like manner get $6\dot{x} \times x^2 + 6x \times$

$2\dot{x}\ddot{x} + 6x\dot{x} \times \ddot{x} + 3x^2 \times \dddot{x}$ (or $6\dot{x}^3 + 18x\dot{x}\ddot{x} + 3x^2\dddot{x}$) for the third fluxion of x^3. Thus also, if $\dot{y} = nx^{n-1}\dot{x}$, then will $\ddot{y} = n \times \overline{n-1} \times x^{n-2}\dot{x}^2 + n\ddot{x}x^{n-1}$; and if $\dot{z}^2 = \dot{x}\dot{y}$, then will $2\dot{z}\ddot{z} = \dot{x}\ddot{y} + \dot{y}\ddot{x}$: and so of others.

The reader is here desired, once for all, to take particular notice, that the fluxions of all kinds and orders whatever, are contemporaneous, or such as may be generated together, with their respective velocities, in one and the same time.

Inverse Method of Fluxions, or the manner of determining the fluents of given fluxions.

If what is already delivered, concerning the direct method, be duly considered, there will be no great difficulty in conceiving the reasons of the inverse method: though the difficulties that occur in this last part, upon another account, are indeed vastly greater. It is an easy matter, or not imposible at most, to find the fluxion of any flowing quantity whatever; but, in the inverse method, the case is quite otherwise; for, as there is no method for deducing the fluent from the fluxion *a priori*, by a direct investigation; so it is impossible to lay down rules for any other forms of fluxions, than those particular ones that we know, from the direct method, belong to such kinds of flowing quantities; thus, for example, the fluent of $2x\dot{x}$ is known to be x^2; because, by the direct method, the fluxion of x^2 is found to be $2x\dot{x}$: but the fluent of $y\dot{x}$ is unknown, since no expression has been discovered that produces $y\dot{x}$ for its fluxion. Be this as it will, the following rules are those used by the best mathematicians, for finding the fluents of given fluxions.

1. To find the fluent of any simple fluxion, you need only write the letters without the dots over them: thus, the fluent of $\dot{x}$ is x, and that of $a\dot{x} + b\dot{y}$, is $ax + by$.

2. To assign the fluent of any power of a variable quantity, multiplied by the fluxion of the root; first divide by the fluxion of the root, add unity to the exponent of the power, and divide by the exponent so increased; for, dividing the fluxion $nx^{n-1}\dot{x}$ by $\dot{x}$, it becomes nx^{n-1}; and adding 1 to the exponent $(n-1)$ we have nx^n; which, divided by n, gives x^n, the true fluent of $nx^{n-1}\dot{x}$. Hence, by the same rule, the fluent of $3x^2\dot{x}$ will $= x^3$; that of $2x^5\dot{x} = \frac{x^6}{3}$; that of $y^{\frac{1}{2}}\dot{y} = \frac{2}{3}y^{\frac{3}{2}}$; that of $ay^{\frac{5}{3}}\dot{y} = \frac{3ay^{\frac{8}{3}}}{8}$; and that of $y^{\frac{m}{n}}\dot{y} = \frac{y^{\frac{m}{n}+1}}{\frac{m}{n}+1} = \frac{ny^{\frac{m+n}{n}}}{m+n}$; that of $\frac{a\dot{x}}{x^n}$, or $a\dot{x}x^{-n}$ $= \frac{ax^{1-n}}{1-n}$; that of $\overline{a+z}|^3 \times \dot{z} = \frac{\overline{a+z}|^4}{4}$; and that of $\overline{a^m + z^m}|^n \times z^{m-1}\dot{z} = \frac{\overline{a^m + z^m}|^{n+1}}{m \times \overline{n+1}}$.

In assigning the fluents of given fluxions, it ought to be considered, whether the flowing quantity, found as above, requires the addition or subtraction of some constant quantity, to render it complete: thus, for instance the fluent of $nx^{n-1}\dot{x}$ may be either represented by x^n or by $x^n \pm a$; for a being a constant quantity, the fluxion of $x^n \pm a$, as well as of x^n, is $nx^{n-1}\dot{x}$.

Hence it appears, that the variable part of a fluent only can be assigned by the common method, the constant part being only assignable from the particular nature of the problem. Now to do this, the best way is to consider how much the variable part of the fluent first found, differs from the truth, when the quantity which the whole fluent ought to express is equal to nothing: then that difference, added to, or subtracted from, the said variable part, as occasion requires, will give the fluent truly corrected. To make this plainer by an example or two, let $\dot{y} = \overline{a+x}|^3 \times \dot{x}$. Here we first find $y = \frac{\overline{a+x}|^4}{4}$; but when $y = 0$, then $\frac{\overline{a+x}|^4}{4}$ becomes $= \frac{a^4}{4}$: since x, by hypothesis, is then $= 0$: therefore $\frac{\overline{a+x}|^4}{4}$ always exceeds y by $\frac{a^4}{4}$; and so the fluent, properly corrected, will be $y = \frac{\overline{a+x}|^4 - a^4}{4} = a^3x + \frac{3a^2x^2}{2} + ax^3 + \frac{x^4}{4}$. Again, let $\dot{y} = \overline{a^m + x^m}|^n \times x^{m-1}\dot{x}$: here we first have $y = \frac{\overline{a^m + x^m}|^{n+1}}{m \times \overline{n+1}}$; and making $y = 0$, the latter part of the equation becomes $\frac{\overline{a^m}|^{n+1}}{m \times \overline{n+1}} = \frac{a^{mn+m}}{m \times \overline{n+1}}$; whence the equation or fluent, properly corrected, is $y = \frac{\overline{a^m + x^m}|^{n+1} - a^{mn+m}}{m \times \overline{n+1}}$. Hitherto x and y are both supposed equal to nothing, at the same time; which will not always be the case: thus, for instance, though the sine and tangent of an arch are both equal to nothing, when the arch itself is so; yet the secant is then equal to the radius. It will therefore be proper to add some examples, in which the value of y is equal to nothing, when that of x is equal to any given quantity a. Thus, let the equation $\dot{y} = x^2\dot{x}$ be proposed; whereof the fluent first found is $y = \frac{x^3}{3}$; but when $y = 0$, then $\frac{x^3}{3} = \frac{a^3}{3}$, by the hypothesis; therefore the fluent, corrected, is $y = \frac{x^3 - a^3}{3}$. Again, suppose $(\dot{y} = \overline{-x^n\dot{x}})$; then will $y = -\frac{x^{n+1}}{n+1}$; which, corrected, becomes $y = \frac{a^{n+1} - x^{n+1}}{n+1}$. And, lastly, if $\dot{y} = \overline{c^3 + bx^2}|^{\frac{1}{2}} \times x\dot{x}$; then, first, $y = \frac{\overline{c^3 + bx^2}|^{\frac{3}{2}}}{3b}$; therefore, the fluent corrected, is $y = \frac{\overline{c^3 + bx^2}|^{\frac{3}{2}} - \overline{c^3 + ba^2}|^{\frac{3}{2}}}{3b}$.

3. To find the fluents of such fluxionary expressions as involve two or more variable quantities, substitute, instead of such fluxion, its respective flowing quantity; and, adding all the terms together, divide the sum by the number of terms, and the quotient will be the fluent. Thus, the fluent of $\dot{x}y + \dot{y}x = \frac{xy + yx}{2} = \frac{2xy}{2} = xy$; and the fluent of $\dot{x}yz + \dot{y}xz + \dot{z}yx = \frac{xyz + xyz + xyz}{3} = \frac{3xyz}{3} = xyz$. But it seldom happens that these kinds of fluxions, which involve two variable quantities in one term, and yet admit of known and perfect fluents, are to be met with in practice.

Having thus shown the manner of finding such fluents as can be truly exhibited in algebraic terms, it remains now to say something with regard to those other forms of expressions involving one variable quantity only; which yet are so affected by compound divisors and radical quantities, that their fluents cannot be accurately determined by any method whatsoever. The only method with regard to these, of which there are innumerable kinds, is to find their fluents by approximation, which, by the method of infinite series, may be done to any degree of exactness. See the article SERIES.

Thus, if it were proposed to find the fluent of $\frac{a\dot{x}}{a-x}$, it becomes necessary to throw the fluxion into an infinite series, by dividing $a\dot{x}$ by $a-x$: thus, $a\dot{x} \div \overline{a-x} = \dot{x} + \frac{x\dot{x}}{a} + \frac{x^2\dot{x}}{a^2} + \frac{x^3\dot{x}}{a^3} + \frac{x^4\dot{x}}{a^4} +$, &c. Now the fluent of each term of this series, may be found by the foregoing rules to be $x + \frac{x^2}{2a} + \frac{x^3}{3a^2} + \frac{x^4}{4a^3} + \frac{x^5}{5a^4} +$, &c.

Again, to approximate the fluent of $\frac{\overline{a^2-x^2}|^{\frac{1}{2}} \times x^n \dot{x}}{\overline{c^2-x^2}|^{\frac{1}{2}}}$, we first find the value of $\frac{\overline{a^2-x^2}|^{\frac{1}{2}}}{\overline{c^2-x^2}|^{\frac{1}{2}}}$, expressed in a series, to be $\frac{a}{c} + \overline{\frac{a}{2c^3} - \frac{1}{2ac}} \times x^2 + \overline{\frac{3a}{8c^5} - \frac{1}{4ac^3} - \frac{1}{8a^3c}} \times x^4 + \overline{\frac{5a}{16c^7} - \frac{3}{16ac^5} - \frac{1}{16a^3c^3} - \frac{1}{16a^5c}} \times x^6 +$, &c. which value being multiplied by $x^n\dot{x}$, and the fluent taken by the rules laid down, we get $\frac{ax^{n+1}}{\overline{n+1} \times c} + \overline{\frac{a}{2c^3} - \frac{1}{2ac}} \times \frac{x^{n+3}}{n+3} + \overline{\frac{3a}{8c^5} - \frac{1}{4ac^3} - \frac{1}{8a^3c}} \times \frac{x^{n+5}}{n+5} + \overline{\frac{5a}{15c^7} - \frac{3}{16ac^5} - \frac{1}{16a^3c^3} - \frac{1}{16a^5c}} \frac{x^{n+7}}{n+7} +$, &c.

In order to show the usefulness of fluxions, we shall give an example or two. Thus, suppose it were required, (1) To divide a given right line AB into two such parts, AC, CB, that their products or rectangles may be the greatest possible. Let $AB = a$, and let the part AC, considered as variable (by the motion of C towards B) be denoted by x. Then BC being $= a - x$, we have $AC \times BC = ax - x^2$, whose fluxion $a\dot{x} - 2x\dot{x}$ being put $= 0$, we get $a\dot{x} = 2x\dot{x}$; and, consequently, $x = \frac{1}{2}a$. Hence it appears that AC (or x) must be half of AB.

(2) To find the fraction which shall exceed its cube by the greatest quantity possible: Let x denote a variable quantity; then the excess of x above x^3, being represented by $x - x^3$, if the fluxion of it be taken, we shall have $\dot{x} - 3x^2\dot{x} = 0$; therefore $1 = 3x^2$, $x^2 = \frac{1}{3}$, and $x = \sqrt{\frac{1}{3}}$.

(3) To determine the greatest rectangle that can be inscribed in a given triangle. See Plate LXIV. Miscel. fig. 91. Put $AC = b$, and its altitude $BD = a$: let the altitude BS of the inscribed rectangle an, considered as variable, be denoted by x. Then, since AC and ac are parallel, it will be BD (a) : AC (b) : : DS $(a-x)$: $\frac{ab-bx}{a}$ = the line ac. And the area of the rectangle, or $ac \times BS = \frac{abx - bx^2}{a}$, the fluxion of which is $\frac{ab\dot{x} - 2bx\dot{x}}{a}$, and being put equal to 0, we have $a = 2x$, and $x = \frac{a}{2}$. Hence the greatest inscribed rectangle is that, the altitude of which is half the altitude of the triangle.

(4) Of all right-angled plain triangles, containing the same given area, to find that of which the sum of the legs AB + BC is the least possible. Let one leg AB be denoted by x, and the area of the triangle by a, then the other leg will be $\frac{2a}{x}$, the fluxion of the sum is $\dot{x} - \frac{2a\dot{x}}{x^2} = 0$: therefore $x^2 = 2a$, and $x = \sqrt{2a}$. Whence BC $= \left(\frac{2a}{x}\right) = \frac{2a}{\sqrt{2a}} = \sqrt{2a}$. Hence the triangle is isosceles.

(5) To determine the dimensions of the least isosceles triangle, ACD, fig. 92, that can circumscribe a given circle. Let the distance OD of the vertex of the triangle from the centre of the circle be called x, and the remaining part OB, or radius, be represented by a; then, if OS perpendicular to DC be drawn, we have $DS = \sqrt{x^2 - a^2}$: and since DS : OS : : DB : BC, we have $BC = \frac{a \times \overline{x+a}}{\sqrt{x^2-a^2}}$, which multiplied by BD or $x + a$, gives $\frac{a \times \overline{x+a}|^2}{\sqrt{x^2-a^2}}$ for the area of the triangle. Which being a minimum, its square is also a minimum, consequently $\frac{\overline{x+a}|^4}{x^2-a^2}$, or its equal $\frac{\overline{x+a}|^3}{x-a}$, a minimum also; the fluxion of which is $\frac{3\dot{x} \times \overline{x+a}|^2 \times \overline{x-a} - \dot{x} \times \overline{x+a}|^3}{\overline{x-a}|^2} = 0$; this being divided by $\frac{\dot{x} \times \overline{x+a}|^2}{\overline{x-a}|^2}$, we get $3 \times \overline{x-a} - \overline{x+a} = 0$, whence $2x = 4a$, and $x = 2a$. Therefore OD is equal

to 2OS, and DC = 2BC = AC; and so the triangle ACD, when the least pssible, is equilateral.

(6) Again, suppose it were required to find the solid content of a spheriod, AFBH (plate LXIV. Micel. fig. 93). Let the axis AB, about which the solid is generated, be $= a$, the radius $= p = 1$, and the other axis FH of the generating ellipsis $= b$; then, from the property of the ellipsis, we have $a^2 : b^2 :: AD \times BD\ (x \times \overline{a - x}) : DE^2\ (y^2)$. Hence $y^2 = \frac{b^2}{a^2} \times \overline{ax - xx}$; and the fluxion of the solid $\dot{s}\ (= py^2\dot{x}) = \frac{pb^2}{a^2} \times \overline{ax\dot{x} - x^2\dot{x}}$; and the solidity $s = \frac{pb^2}{a^2} \times \frac{1}{2}axx - \frac{1}{3}x^3 =$ the segment AIE; which, when AD $(x) =$ AB (a), becomes $\left(\frac{pb^2}{a^2} \times \frac{1}{2}a^3 - \frac{1}{3}a^3\right) \frac{1}{6}pab^2 =$ the content of the whole spheroid Where, if b (FH) be taken $= a$ (AB), we shall get $\frac{1}{6}pa^3$ for the true content of the sphere, whose diameter is a. Hence a sphere or spheriod is $\frac{2}{3}$ of its circumscribing cylinder: for the area of the circle FH being expressed by $\frac{pb^2}{4}$, the content of the cylinder, whose diameter is FH, and altitude AB, will be $\frac{pb^2a}{4}$; of which $\frac{1}{6}pab^2$ is evidently two-third parts.

[The preceding articles serve to show the general principles of the doctrine of fluxions; but the reader who is desirous of obtaining more information on the subject is referred to the following authors, viz. Woodhouse, Vince, and Simpson. It is often convenient for the mathematician to have a table of fluents which will serve for the more readily finding the fluents of other expressions. The following table exhibits the fluxions, and opposite to them the corresponding fluents.

N. B. The logarisms here used are of the hyperbolic kind.

FLUXIONS.	FLUENTS.
$\overline{a^n + bx^n}\rceil^m \times x^{n-1}\dot{x}.$	$\left.\frac{\overline{a^n + bx^n}\rceil^{m+1} - \overline{a^n + bc^n}\rceil^{m+1}}{bn . \overline{m+1}}\right\}$ $c = x$ when $fl = 0$.
$\frac{x^{nm-1}\dot{x}}{\overline{a^n + bx^n}\rceil^{m+1}}.$	$\left.\frac{1}{nma^n} \times \frac{x^{nm}}{\overline{a^n + bx^n}\rceil^m} - \frac{c^{nm}}{\overline{a^n + bc^n}\rceil^m}.\right\}$ $c = x$ when $fl = 0$.
$\frac{x^{n-1}\dot{x}}{(a^{2n} - x^{2n})^{\frac{1}{2}}}.$	$\left.C + \frac{1}{na^n} \times \text{circular arc. rad. } a^n\text{, sine } x^n.\right\}$ C is the correction to be applied.
$\frac{x^{n-1}\dot{x}}{a^{2n} + x^{2n}}.$	$C + \frac{1}{na^{2n}} \times \text{circ. arc. rad. } a^n\text{, tang } x^n.$
$\left.\frac{\dot{x}}{\overline{a + bx} \cdot \overline{d + ex}}\right\} \frac{d}{e} >$ or $< \frac{a}{b}$	$\left.\frac{1}{bd - ae} \times \log. \frac{d + ec}{a + bc} \times \frac{a + bx}{d + ex}\right\}$ $c = x$ when $fl = 0$.
$\dot{x}(dx - x^2)^{\frac{1}{2}}.$	$\frac{1}{2}$ circ. seg. to diameter d and versed sine x.
$\dot{x}y^x \log. y + xy^{x-1}\dot{y}.$	$y^x.$
$\frac{\dot{x}}{(a^2 + 2bdx - d^2x^2)^{\frac{1}{2}}}.$	$C + \frac{1}{d} \times \text{circ. arc. rad. 1. sine } \frac{dx - b}{(a^2 + b^2)^{\frac{1}{2}}}.$
$\frac{\dot{x}}{(a^2 + 2bdx + d^2x^2)^{\frac{1}{2}}}.$	$C + \frac{1}{d} \times \log. \overline{b + dx + (a^2 + 2bdx + d^2x^2)^{\frac{1}{2}}}.$
$c^{nx}\dot{x}.$	$\frac{c^{nx}}{n. \log. c}.$
$\frac{x^{\frac{1}{2}n - 1}\dot{x}}{(\pm a + x^n)^{\frac{1}{2}}}.$	$\frac{2}{n} \log. x^{\frac{n}{2}} + (\pm a + x^n)^{\frac{1}{2}}.$

FLUXIONS.	FLUENTS.
$\frac{x^3\dot{x}}{a-x}$.	$-\frac{1}{3}x^3-\frac{1}{2}ax^2-a^2x+a^3\times\log.\ (a-x)$.
$cx\dot{x}\times\frac{d^2x^2+2adhx+a^2h^2}{h^2}$.	$ch^2\times\frac{3d^2+8ad+6a^2}{12}\Big\}\ x=h$.
$(a+x^n)^m x^{2n-1}\dot{x}$.	$\frac{(a+x^n)^{m+1}}{n}\times\frac{(m+1)x^n-a}{m+1.\ m+2}$.
$5(\frac{1}{3}-z^2)^{\frac{1}{2}}z^{-8}\dot{z}$.	$\frac{-3(\frac{1}{3}-z^2)^{\frac{3}{2}}}{7z^7}\times(5+12z^2+24z^4)$. [r]

FLY, in zoology, a large order of insects, the distinguishing characteristic of which is, that their wings are transparent; by this they are distinguished from beetles, butter-flies, and grasshoppers. See MUSCA.

FLY, in mechanics, a cross with leaden weights at its ends, or rather a heavy wheel at right angles to the axis of a windlass, jack, &c.; by means of which the force of the power, whatever it may be, is not only preserved, but equally distributed in all parts of the revolution of the machine. See MECHANICS.

The fly may be applied to several sorts of engines, whether moved by men, horses, wind, or water, or any other animate or inanimate power; and is of great use in those parts of an engine which have a quick circular motion, and where the power or the resistance acts unequally in the different parts of a revolution. This has made some people imagine, that the fly adds a new power; but though it may be truly said to facilitate the motion, by making it more uniform, yet upon the whole it causes a loss of power, and not an increase; for as the fly has no motion of its own, it certainly requires a constant force to keep it in motion; not to mention the friction of the pivots of the axis, and the resistance of the air. The reason, therefore, why the fly becomes useful in many engines, is not that it adds a new force to them; but because, in cases where the power acts unequally, it serves as a moderator to make the motion of revolution almost every where equal: for as the fly has accumulated in itself a great degree of power, which it equally and gradually exerts, and as equally and gradually receives, it makes the motion in all parts of the revolution pretty nearly equal and uniform. The consequence of this is, that the engine becomes more easy and convenient to be acted on and moved by the impelling force; and this is the only benefit obtained by the fly.

The best form for a fly, is that of a heavy wheel or circle, of a fit size, as this will not only meet with less resistance from the air, but being continuous, and the weight every where equally distributed through the perimeter of the wheel, the motion will be more easy, uniform, and regular. In this form, the fly is more aptly applied to the perpendicular drill, which it likewise serves to keep upright by its centrifugal force: also to a windlass or common winch, where the motion is quick; for in pulling upwards from the lower part, a person can exercise more power than in thrusting forward in the upper quarter; where, of course, part of his force would be lost, was it not accumulated and conserved in the equable motion of the fly. Hence, by this means, a man may work all day in drawing up a weight of 40lb. whereas 30lb. would create him more labour in a day without the fly.

In order to calculate the force of the fly joined to the screw for stamping the image upon coins, let us suppose the two arms of the fly to be each fifteen inches long, measuring from the centre of the weight to the axis of motion, the weight to be fifty pounds each, and the diameter of the axis pressing upon the dye, to be one inch. If every stroke is made in half a second, and the weights describe an half-circumference, which in this case will be four feet, the velocity will at the instant of the stroke be at the rate of eight feet in a second, so that the momentum of it will be 800; but the arms of the fly being as levers, each fifteen inches long, whilst the semi-axis is only half an inch, we must increase this force thirty times, which will give 24000; an immense force equal to 100lb. falling 120 feet, or near two seconds in time; or to a body of 750lb. falling $16\frac{1}{12}$ feet, or one second in time. Some of the engines for coining crown-pieces have the arms of the fly five times as long, and the weights twice as heavy; so that the effect is ten times greater.

FLY, in the sea-language, that part of the mariner's compass, on which the several winds or points are drawn.

Let fly the sheet, is a word of command to let loose the sheet, in case of a gust of wind, lest the ship should overset, or spend her topsails and masts; which is prevented by letting the sheet go amain, that it may hold no wind.

FLY-BOAT, a large vessel with a double prow, carrying from seven to eight hundred weight of goods.

FLY, *vegetable*, a very curious natural production, chiefly found in the West Indies. Excepting that it has no wings, it resembles the drone both in size and colour more than any other British insect. In the month of May it buries itself in the earth, and begins to vegetate. By the end of July, the tree is arrived at its full growth, and resembles a coral branch; and is about three inches high, and bears several little pods, which dropping off become worms, and thence flies, like the British caterpillar. Such was the account originally given of this extraordinary production. But several

boxes of these flies having been sent to Dr. Hill for examination, his report was this: "There is in Martinique a fungus of the clavaria kind, different in species from those hitherto known. It produces soboles from its sides; I call it therefore clavaria sobolifera. It grows on putrid animal bodies, as our fungus ex pede equino, from the dead horse's hoof. The cicada is common in Martinique, and in its nympha state, in which the old authors call it tettigometra: it buries itself under dead leaves to wait its change; and when the season is unfavourable, many perish. The seeds of the clavaria find a proper bed in this dead insect, and grow. The tettigometra is among the cicadæ in the British museum; the clavaria is just now known. This is the fact, and all the fact; though the untaught inhabitants suppose a fly to vegetate, and though there is a Spanish drawing of the plants growing into a trifoliate tree, and it has been figured with the creature flying with this tree upon its back." Edwards has taken notice of this extraordinary production in his Gleanings of Natural History.

FLYERS, in architecture, such stairs as go straight, and do not wind round.

FLYING, the progressive motion of a bird, or other winged animal, in the liquid air. The parts of birds chiefly concerned in flying, are the wings, by which they are sustained or wafted along. The tail, Messrs. Willughby, Ray, and many others, imagine to be principally employed in steering and turning the body in the air, as a rudder; but Borelli has put it beyond all doubt, that this is the least use of it, which is chiefly to assist the bird in its ascent and descent in the air; and to obviate the vacillations of the body and wings: for, as to turning to this or that side, it is performed by the wings and inclinations of the body, and but very little by the help of the tail. The flying of a bird, in effect, is quite a different thing from the rowing of a vessel. Birds do not vibrate their wings towards the tail, as oars are struck towards the stern, but waft them downwards; nor does the tail of the bird cut the air at right angles, as the rudder does the water, but is disposed horizontally, and preserves the same situation what way soever the bird turns.

In effect, as a vessel is turned about on its centre of gravity to the right, by a brisk application of the oars to the left, so a bird in beating the air with its right wing alone, towards the tail, will turn its fore part to the left. Thus pigeons, changing their course to the left, would labour with their right wing, keeping the other almost at rest. Birds of a long neck alter their course by the inclinations of their head and neck, which altering the course of gravity, the bird will proceed in a new direction.

The manner of flying is thus: The bird first bends his legs, and springs with a violent leap from the ground; then opens and expands the joints of his wings, so as to make a right line perpendicular to the sides of his body: thus the wings, with all the feathers in them, constitute one continued lamina. Being now raised a little above the horizon, and vibrating the wings with great force and velocity perpendicularly against the subject air, that fluid resists those succussions, both from its natural inactivity and elasticity, by means of which the whole body of the bird is protruded. The resistance the air makes to the withdrawing of the wings, and consequently the progress of the bird, will be so much the greater, as the waft or stroke of the fan of the wing is longer; but as the force of the wing is continually diminished by this resistance, when the two forces come to be in equilibrio, the bird will remain suspended in the same place: for the bird only ascends so long as the arch of air the wing describes, makes a resistance equal to the excess of the specific gravity of the bird above the air. If the air, therefore, is so rare as to give way with the same velocity that it is struck with, there will be no resistance, and consequently the bird can never mount. Birds never fly upwards in a perpendicular line, but always in a parabola. In a direct ascent, the natural and artificial tendency would oppose and destroy each other, so that the progress would be very slow. In a direct descent they would aid one another, so that the fall would be too precipitate.

Artificial FLYING, that attempted by men, by the assistance of mechanics.

The art of flying has been attempted by several persons in all ages. The Leucadians, out of superstition, are reported to have had a custom of precipitating a man from a high cliff into the sea, first fixing feathers, variously expanded, round his body, in order to break his fall. Friar Bacon, who lived five hundred years ago, not only affirms the art of flying possible, but assures us, that he himself knew how to make an engine in which a man sitting might be able to convey himself through the air, like a bird; and further adds, that there was then one who had tried it with success; but this method, which consisted of a couple of large, thin, hollow, copper globes, exhausted of the air, and sustaining a person who sat thereon, Dr. Hook shows to be impracticable. The philosophers of king Charles the Second's reign, were exceedingly busied about this art. The famous bishop Wilkins was so confident of success in it, that he says, he does not question that, in future ages, it will be as usual to hear a man call for his wings, when he is going a journey, as it is now to call for his boots.

FLYING ARMY, a small body under a lieutenant or major-general, sent to harass the country, intercept convoys, prevent the enemy's incursions, cover its own garrisons, and keep the enemy in continual alarm.

FLYING PINION, is part of a clock, having a fly, or fan, whereby to gather air, and so bridle the rapidity of the clock's motion, when the weight descends in the striking part. See CLOCKWORK.

FOCUS, in geometry and conic sections, is applied to certain points in the parabola, ellipsis, and hyperbola, where the rays reflected from all parts of these curves concur and meet.

FOCI of an ellipsis, are two points in the longest axis, on which as centres the figure is described. If from the foci two right lines are drawn, meeting one another in the periphery of the ellipsis, their sum will be always equal to the longest axis; and therefore when an ellipsis and its two axis are given, and the foci are required, you need only take half the longest axis in your compasses, and setting one foot in the end of the shorter, the other foot will cut the longer in the focus required.

FOCUS of an hyperbola, is that point in the axis, through which the latus rectum passes; from whence if

any two right lines are drawn meeting in either of the opposite hyperbolas, their difference will be equal to the principal axis.

Focus *of a parabola*, a point in the axis within the figure, distant from the vertex one fourth part of the latus rectum.

Focus, in optics, is the point in which the rays are collected, after they have undergone reflection or refraction. See Optics.

FODDER, in the civil law, is used for a prerogative that the prince has, to be provided of corn, and other meats for his horses, by the subjects, in his warlike expeditions.

Fodder, or Fother, in mining, a measure containing twenty-two hundred and a half weight, though in London but twenty hundred weight.

FOETUS. See Physiology.

FOG, or Mist, a meteor, consisting of condensed vapours, floating near the surface of the earth. Mists, according to lord Bacon, are imperfect condensations of the air, consisting of a large proportion of the air, and a small one of the aqueous vapour: and these happen in the winter, about the change of the weather from frost to thaw, or from thaw to frost; but in the summer and in the spring, from the expansion of the dew. If the vapours, which are raised plentifully from the earth and waters, either by the solar or subterraneous heat, do at their first entrance into the atmosphere meet with cold enough to condense them to a considerable degree, their specific gravity is by that means increased, and thus they will be stopped from ascending; and either return back in form of dew or of drizzling rain, or remain suspended some time in the form of a fog. Vapours may be seen on the high grounds as well as the low, but more especially about marshy places. They are easily dissipated by the wind, as also by the heat of the sun. They continue longest in the lowest grounds, because those places contain most moisture, and are least exposed to the action of the wind. Hence we may easily conceive, that fogs are only low clouds, or clouds in the lowest region of the air; as clouds are no other than fogs raised on high. When fogs stink, then the vapours are mixed with putrid and offensive exhalations. Objects viewed through fogs appear larger and more remote than through the common air. Mr. Boyle observes that, upon the coast of Coromandel, and most maritime parts of the East Indies, there are, notwithstanding the heat of the climate, annual fogs, so thick, as to occasion people of other nations who reside there, and even the more tender sort of the natives, to keep their houses close shut up. Fogs are commonly pretty strongly electrified, as appears from Mr. Cavallo's experiments upon them. See Meteorology.

FOIL, among glass-grinders, a sheet of tin, with quicksilver, &c. laid on the back-side of a looking-glass, to make it reflect. See Foliating of Looking-glasses.

Foil, among jewellers, a thin leaf of metal placed under a precious stone, in order to increase its brilliancy, or give it an agreeable and different colour. These foils are made either of copper, gold, or gold and silver together; the copper foils are commonly known by the name of Nuremberg, or German foils; they are prepared as follows: Procure the thinnest copper-plates you can get; beat these plates gently upon a well-polished anvil, with a polished hammer, as thin as possible; and placing them between two iron plates as thin as writing-paper, heat them in the fire; then boil the foils, in a pipkin, with equal quantities of tartar and salt, constantly stirring them till by boiling they become white; after which, taking them out, and drying them, give them another hammering till they are made fit for your purpose; however, care must be taken not to give the foils too much heat, for fear of melting, nor must they be too long boiled, for fear of attracting too much salt.

The manner of polishing these foils is as follows: take a plate of the best copper, one foot long, and about five or six inches wide, polished to the greatest perfection; bend this to a long convex, fasten it upon a half roll, and fix it to a bench or table; then take some chalk, washed as clean as possible, and filtred through a fine linen-cloth, till it is as fine as you can make it; and having laid some on the roll, and wetted the copper all over, lay your foils upon it, and with a polishing stone and the chalk, polish your foils till they are bright as a looking-glass; after which they must be dried, and laid up secure from dust.

FOLD-net, among sportsmen, a sort of net with which small birds are taken in the night, of which there are two sorts; the least may be managed by one man only, but the greatest must be carried by two, and used thus: let the net be fixed on both sides to two strong, straight, and light poles about twelve feet long, each man holding one of them; let there be one behind them, at the distance of two yards, to carry lights: the nets must be carried between the wind and the birds, which all naturally roost on their perches with their breasts against the wind; in consequence of this, he that beats the bushes on the other side of the hedge, will drive them out that way towards the light.

FOLDING *of sheep*. See Husbandry.

FOLIAGE, in architecture, is used for the representations of such flowers, leaves, branches, rinds, &c. whether natural or artificial, as are used for enrichments on capitals, friezes, pediments, &c.

FOLIATE, in the higher geometry, a name given by Mr. de Moivre to a curve of the second order, expressed by the equation $x^3+y^3=axy$; being a species of defective hyperbolas with one asymptote, and consisting of two infinite legs crossing one another, and forming a sort of leaf.

FOLIATING *of looking-glasses*, the spreading the plates over, after they are polished, with amalgam, in order to reflect the image. It is performed thus: a thin blotting paper is spread on the table, and sprinkled with fine chalk; and then a fine lamina or leaf of tin, called foil, is laid over the paper; upon this mercury is poured, which is to be distributed equally over the leaf with a hare's foot, or cotton: over this is laid a clean paper, and over that the glass plate, which is pressed down with the right-hand, and the paper drawn gently out with the left: this being done, the plate is covered with a thicker paper, and loaden with a greater weight, that the superfluous mercury may be driven out, and the tin adhere more closely to the glass. When it is dried, the weight is removed, and the looking-glass is complete. Some add an ounce of marcasite, melted by the fire; and, lest the mer-

cury should evaporate in smoke, pour it into cold water; and when cooled, squeeze it through a cloth or through leather.

Some add a quarter of an ounce of tin and lead to the marcasite, that the glass may dry the sooner.

FOLIATING *of globe looking-glasses*, is done as follows: Take five ounces of quick-silver, and one ounce of bismuth; of lead and tin half an ounce each: first put the lead and tin into fusion, then put in the bismuth, and when you perceive that in fusion too, let it stand till it is almost cold, and pour the quick-silver into it; after this, take the glass globe, which must be very clean, and the inside free from dust; make a paper funnel, which put into the hole of the globe, as near to the glass as you can, so that the amalgam when you pour it in, may not splash, and cause the glass to be full of spots; pour it in gently, and move it about, so that the amalgam may touch every where. If you find the amalgam begin to get curdly and fixed, then hold it over a gentle fire, and it will easily flow again. And if you find the amalgam too thin, add a little more lead, tin, and bismuth to it. The finer and clearer your globe is, the better will the looking-glass be.

FOLKMOTE, or FOLCMOTE, according to Kennet, was the common-council of all the inhabitants of a city, town, or borough; though Spelman will have the folkmote to have been a sort of annual parliament or convention of the bishops, thanes, aldermen, and freemen, on every May-day. Dr. Brady, on the contrary, tells us, that it was an inferior court, held before the king's-reeve, or his steward, every month, to do folk right.

FOMAHAUT, in astronomy, a star of the first magnitude, in the constellation Aquarius. See ASTRONOMY.

FOMENTATION, in medicine, the bathing any part of the body with a warm liquor.

FONTEVRAUD, or order of Fontevraud, a religious order instituted about the latter part of the 11th century. By the rules of this order the nuns were to keep silence for ever, and their faces to be always covered with their veils; and the monks wore a leathern girdle, at which hung a knife and sheath.

FONTANESIA, a genus of the diandria monogynia class and order. The calyx is four-parted, inferior: petals two, two-parted: capsule membranaceous, not opening, two-celled, one-seeded. There is one species, an herb of Syria.

FONTINALIS, water-moss, a genus of the natural order of musci, in the cryptogamia class of plants. The anthera is hooded; the calyptra, or covering of the anthera, sessile, inclosed in a perichætium or empalement of leaflets different from those of the rest of the plant. There are six species, all of them natives of Britain. They grow on the brinks of rivulets, and on the trunks of trees. The most remarkable is the antipyretica, with purple stalks. The Scandinavians line the insides of their chimneys with this moss, to defend them against the fire; for, contrary to the nature of all other mosses, this is scarcely capable of burning.

FOOD. See MATERIA MEDICA.

FOOD of plants. See PLANTS.

FOOT, a part of the body of most animals whereon they stand, walk, &c.

Animals are distinguished with respect to the number of their feet, into bipedes, two-footed; such are men and birds: quadrupeds, four-footed; which are most land animals; and multipedes, or many-footed, as insects. The reptile kind, as serpents, &c. have no feet; the crab kind of fish have ten feet, but most other fishes have no feet at all: the spider, mites, and polypuses, have eight; flies, grasshoppers, and butterflies, have six feet. Animals destined to swim, and water-fowl, have their toes webbed together, as the phocæ, goose, duck, &c. The fore feet of the mole, rabbit, &c. are wonderfully formed for digging and scratching up the earth, in order to make way for their head.

FOOT, in the Latin and Greek poetry, a metre or measure composed of a certain number of long and short syllables. These feet are commonly reckoned twenty-eight, of which some are simple, as consisting of two or three syllables, and therefore called disyllabic or trisyllabic feet; others are compound, consisting of four syllables, and are therefore called tetrasyllabic feet.

FOOT is also a long measure, consisting of twelve inches. Geometricians divide the foot into ten digits, and the digit into ten lines.

FOOT, *square*, is the same measure both in breadth and length, containing 144 square or superficial inches.

FOOT, *cubic*, or *solid*, is the same measure in all the three dimensions, length, breadth, and depth or thickness, containing 1728 cubic inches. The foot is of different lengths in different countries. The Paris royal foot exceeds the English by nine lines; the ancient Roman foot of the capitol, consisted of 4 palms, equal to $11\frac{7}{10}$ inches English; Rhineland or Leyden foot, by which the northern nations go, is to the Roman foot as 950 to 1000. The proportions of the principal feet of several nations, compared with the English, are as follow.

The English foot being divided into 1000 parts, or into 12 inches, the other feet will be as follow:

	1000 parts.	feet.	inch.	lines.
London or American foot	1000	0	12	0
Amsterdam	942	0	11	3
Antwerp	946	0	11	2
Bologna	1204	1	2	4
Bremen	964	0	11	6
Cologne	954	0	11	4
Copenhagen	965	0	11	6
Dantzick	944	0	11	3
Dort	1184	1	2	2
Frankfort on the Maine	948	0	11	4
The Greek	1007	1	0	1
Lorrain	958	0	11	4
Mantua	1569	1	6	8
Mechlin	919	0	11	0
Middleburg	991	0	11	9
Paris royal	1068	1	0	9
Prague	1026	1	0	3
Rhineland or Leyden	1033	1	0	4
Riga	1831	1	9	9
Roman	967	0	11	6
Old Roman	970	0	11	8
Scotch	1005	1	0	$\frac{5}{7}$
Strasburg	920	0	11	0
Toledo	899	0	10	7
Turin	1062	1	0	7
Venice	1162	1	1	9

Foot of the forest, pes forestæ, in our ancient customs, contained eighteen inches, or $1\frac{1}{2}$ of the common foot.

Foot-level, among artificers, an instrument that serves as a foot-rule, a square, and a level. See the articles Level, Rule, and Square.

Foot-pace, or Half-pace, among carpenters, a pair of stairs, whereon, after four or six steps, you arrive at a broad place, where you may make two or three paces before you ascend another step. The design of this is, to ease the legs in ascending the rest of the steps.

FORAMEN, in anatomy, a name given to several apertures or perforations in divers parts of the body.

FORCE, in mechanics, denotes the cause of the change in the state of a body when being at rest it begins to move, or has a motion which is either not uniform, or not direct. See Mechanics.

FORCE, in our common law, is most usually applied in its worst sense, signifying unlawful violence. Force is either simple or compound: simple force is that which is so committed, that it is accompanied by no other crime; as if one by force shall enter into another man's possession, without doing any other unlawful act; mixed or compound force, is that violence which is committed with such a fact, as of itself only is criminal; as if one by force enters into another man's possession, and kills a man, or ravishes a woman there, &c.

All force is against law; and it is lawful to repel force by force. 1 Inst. 267.

Where a crime, in itself capital, is endeavoured to be committed by force, it is lawful to repel that force, by the death of the party attempting. 4 Black. 181.

FORCEPS, in surgery, &c. a pair of scissars for cutting off, or dividing, the fleshy membranous parts of the body, as occasion requires. See Surgery.

FORCER, or Forcing-pump, in mechanics, is a kind of pump in which there is a force or piston without a valve. See Hydraulics, and Fire-engine.

FORCIBLE entry and detainer. Forcible entry is a violent actual entry into a house or land, &c. or taking a distress of any person weaponed, whether he offers violence or fear of hurt to any there, or furiously drives any out of the possession thereof. West. Symbol. p. 2.

Where one or more persons armed with unusual weapons, violently enter into the house or land of another; or where they do not enter violently, if they forcibly put another out of his possession; or if one enters another's house without his consent, although the doors be open, &c. these are all forcible entries punishable by the law. Co. Lit. 257. So when a tenant keeps possession of the land at the end of his term against the landlord, it is a forcible detainer. 1 Haw. 145.

If any person is put out or disseised of any lands and tenements in a forcible manner; or put out peaceably, and after holden out with strong hand; the party grieved shall have assize of novel disseisin, or writ of trespass against the disseisor; and if he recovers (or if any alienation is made to defraud the possessor of his right, which is also declared by the statute to be void), he shall have treble damages, and the defendant shall also make fine and ransom to the king. 8 H. VI. c. 9. But as this action is at the suit of the party, and only for the right, it lies only where the entry for the defendant was not lawful; for though a man enters with force, where his entry is lawful, he shall not be punished by way of action, but he may be indicted by the statute, for the indictment is for the force and for the king, and he shall make fine to the king, be his right ever so good. Dalt. c. 129. He shall recover treble damages, as well for the mesne occupation, as for the first entry; and though he shall recover treble damages, he shall recover costs which shall be treble also; for the word damages includes costs of suit. 1 Inst. 257.

An indictment will lie at common law for a forcible entry, though generally brought on the statutes; but it must show on the face of it sufficient actual force. 3 Bur. 1702.

If the party grieved will lose the benefit of his treble damages and costs, he may have the assistance of the justices at the general session, by way of indictment on the statute 8 H. VI. which being found there, he shall be restored to his possession by a writ of restitution granted out of the same court to the sheriff. Dalt. c. 129.

Forcible entry and detainer is also punishable under the statute, by one justice of peace, and by certiorari. Dalt. c. 44.

Forcible marriage. If any person shall take away any woman having lands or goods, or that is heir apparent to her ancestor, by force and against her will, and afterwards she be married to him, or to another by his procurement, or defiled; he and also the procurers and receivers of such a woman, shall be adjudged principal felons. And by 39 Eliz. c. 9, the benefit of clergy is taken away from the principals, procurers, and accessaries before. And by 4 and 5 P. et M. c. 8, if any person shall take or convey away any unmarried woman under the age of sixteen (though not attended with force), he shall be imprisoned two years, or fined at the discretion of the court; and if he deflower her, or contract matrimony without consent of parents or guardians, he shall be imprisoned five years or fined, and the marrying of any person under 21 without such consent is void.

FORCING, among gardeners, signifies the making trees produce ripe fruit before their usual time.

Forcing of wine. See Wine.

FORE-Castle, *of a ship*, that part where the foremast stands. It is divided from the rest by a bulk-head. See Ship.

Fore-closed, in law, signifies the being shut out, and excluded or barred, the equity of redemption on mortgages, &c. See Mortgage.

Fore-foot, in the sea-language, signifies one ship's lying, or sailing, across another's way; as if two ships being under sail, and in ken of one another, one of them lying in her course with her stem so much a weather the other that holding on their several ways, neither of them altering their courses, the windward ship will run ahead of the other; then it is said, such a ship lies with the other's forefoot.

FOREIGN *attachment*, is an attachment of the goods of foreigners, found within a city or liberty, for the satisfaction of some citizen to whom the foreigner is indebted; or it signifies an attachment of a foreigner's money in the hands of another person.

Foreign *courts*. Upon a principle of the law of nations, every state being free, independent, and uncon-

trolable, the sentence of any foreign court of competent jurisdiction, is not to be called in question, but is admitted as evidence of the fact upon which it is founded. If however in such sentence any foreign jurisdiction should state the evidence, upon which its sentence or device is founded, subsequent evidence may be admitted to disprove such evidence, and consequently the sentence or decree which is a deduction from it. But where it is peremptorily given as a sentence, it is conclusive evidence which the English courts will not allow to be questioned.

FOREIGNERS, are persons subject to a foreign state to which they owe an allegiance, and although made free denizens or naturalized in Great Britain, they are nevertheless expressly disabled by the act of settlement from bearing offices in the government, from being members of the privy council, or members of parliament. See ALIEN.

FOREIGN *opposer*, or *apposer*, an officer in the exchequer to whom all sheriffs, after they are apposed of their sums out of the pipe-office, repair to be apposed by him of their green wax. He examines the sheriff's estreats with the record, and apposes the sheriff, what he says to every particular sum therein.

FOREIGN *plantations:* a writ of error lies here upon any of the judgments in foreign plantations, or in any dominions belonging to England. Vaugh. 402.

FOREIGN *plea:* a foreign plea is where the action is carried out of the county where it is laid, and is to be sworn, which a plea to the jurisdiction is not. Carth. 402.

FOREIGN *service*, is that whereby a mesne lord holds over of another, without the compass of his own fee; or that which a tenant performs either to his own lord, or to the lord paramount out of the fee. Bracton, lib. 2. c. 16.

FOREIGN *state*, is the dominion of a foreign power. Thus, if any foreign subject purchase goods in London, and then depart privately to his own country, the owner of the goods may have a certificate from the lord-mayor of London, on an affidavit being made of the sale and delivery of the goods, upon which the proper court in that state, will execute a legal process upon the party. At the instance of an embassador also or consul, any criminal flying from justice to any foreign state, may be delivered up to the laws of the country where the crime was committed. Where any contract is made abroad if the party is resident in England, it may be recovered by the English courts.

FOREIGN *seamen*, serving two years on board British ships, whether of war, trade, or privateers, during the time of war, shall be deemed natural-born subjects.

FOREJUDGER, a judgment whereby a man is deprived, or put out, of the thing in question.

FOREJUDGED *the court*, is when an officer or attorney of the court of common pleas is expelled the same for some offence, or for not appearing to an action by bill filed against him; and in the latter he is not to be readmitted till he shall appear. By 2 H. IV. c. 8. he shall lose his office and be forejudged the court.

FORLORN-HOPE, in the military art, signifies men detached from several regiments, or otherwise appointed, to make the first attack in day of battle, or at a siege, to storm the counterscarp, mount the breach, &c.

FOREMAST of a ship, that which carries the foresail and fore-top-sail yards. Its length is usually $\frac{8}{9}$ of the mainmast; and the fore-top-gallant-mast is $\frac{1}{2}$ the length of the fore-top-mast.

FOREMAST-MEN, are those on board a ship that take in the top-sails, sling the yards, furl the sails, bowse, trice, and take their turn at the helm, &c.

FORE-REACH, in the sea-language: a ship is said to fore-reach upon another, when both sailing together, one sails better, or outgoes the other.

FORESTS, in England are waste grounds belonging to the king, replenished with all manner of beasts of chace or venery, which are under the king's protection, for the sake of his royal recreation and delight; and to that end, and for the preservation of the king's game, there are particular laws, privileges, courts and officers, belonging to the king's forests. 1 Black. 279.

The forest courts are, the courts of attachments, of regard, of swainmote, and of justice seat.

The court of attachments is to be held before the verderers of the forest, once in every forty days, to inquire of all offenders against the king's deer, or covert for the game, who may be attached by their bodies, if found in the very act of transgression, otherwise by their goods; and in this court the forests are to bring in their attachment, or presentments of vert and venison: and the verderers are to receive the same, and to enroll them, and to certify them under their seals, to the court of justice seat, or swainmote, for this court can only inquire of but not convict offenders.

The court of regard or survey of dogs is be holden every third year, for the lawing or expeditating of mastiffs, which is done by cutting of the claws of the forefeet, to prevent them from running after deer. No other dogs than mastiffs were permitted to be kept within the king's forests, it being supposed that the keeping of these, and these only, was necessary for the defence of a man's house.

The court of swainmote is to be holden before the verderers as judges, by the steward of the swainmote, thrice in every year, the swains or freeholders within the forest composing the jury. The jurisdiction of this court, is, to inquire into the oppressions and grievances committed by the officers of the forest, and to receive and try presentments certified from the court of attachments, against the offenders in vert and venison; and this court may not only inquire, but convict also, which conviction shall be certified to the court of justice seat, under the seals of the jury, for this court cannot proceed to judgment.

The court of justice seat, is the principal court; which is held before the chief justice in eyre, or chief itinerant judge, or his deputy, to hear and determine all trespasses within the forest, and all claims of franchises, liberties, and privileges, and all pleas and causes whatsoever therein arising. It may also proceed to try presentments made in the inferior courts of the forest, and to give judgment upon the convictions that have been made in the swainmote courts. It may be held every third year. This court may fine and imprison, it being a court of record: and a writ of error lies to the court of king's bench. 1 Black. 289. 2 Black. 38. 3 Black. 71. But the

forest laws have long ago ceased to be put in execution. 1 Black. 289.

Forest-trees. The planting of forest-trees is profitable as well as pleasing and respectable; and a young planter may live to reap much reward from his labour, or he may leave a valuable inheritance to his children. "The plantation and care of timber is like buying the reversion of an estate; for a little money expended, we become heirs to great sums. In countries scarce of firing, and where poles and rails are wanted, underwood will pay the proprietor triple more in value than the best fields of corn, and the oaks among it remain a great estate to succeeding generations." Poor land, that does not for corn, would be profitably cultivated in wood; but such ground should be sown, rather than planted. Wet places may be advantageously planted with the amphibious tribe, as willow, sallow, withy, osier, &c.

For those who may be disposed to plant forest-trees, the following directions are offered: The manual work proper to this business, is nearly the same as for fruit-trees and shrubs; and though plantations of forest-trees need not be so nicely attended to as fruit-trees, yet the better the work is performed, the fairer is the prospect in growing good timber: a check by an error at first planting is a loss of time, and a damage done to trees which is sometimes never recovered. To give an instance: the mould is often thrown on the root of a forest-tree in lumps, when if a little sifted earth was used, so as just to cover them with fine mould, the trouble would be amply repaid by the quick striking, and future strength of the tree.

Ground designed for planting should be prepared as long as it can beforehand, by the use of the plough or spade; and if some sort of previous cultivation, either in corn or vegetables, was adopted, the soil would be better fitted to receive the trees. At any rate, the places where the trees are to be set, should be previously dug somewhat deep, and cleared of rubbish, perennial weeds, tcouch, &c. If wet, let it be properly drained, for none but aquatics can do well in a cold and very moist soil.

In open planting for timber, to make only the holes good where the trees are set, is sufficient, if the soil is not strong (which generally speaking however it should be); and in such plantations the plough being used for corn, or some sort of crop to be carried off, the whole soil will be prepared for the trees' roots to spread. A plantation of this sort may be constantly under the plough, till the trees shade too much; and then it may be sown down for grass, which lying warm, and coming early, would be found useful. The opportunity given to improve a soil by this cultivation, would insure very fine timber.

But a plantation of trees being made (as suppose of oaks) at due distances, and the ground ploughed for two or three years, while they got a little ahead, then it might be sown profitably, with nuts, keys, and seeds for underwood, observing to thin the plants the second year, and again the third, till two or three feet asunder in poor ground, and to three or four feet distance if rich. In fourteen or fifteen years (or much sooner for some purposes), the ash-poles, &c. will be fine, and meet with a ready sale as useful stuff: afterwards the underwood will be fit to cut, in a strong state, every eleven or twelve years. In the management of underwood, some have thinned the plants while young, to three feet asunder, and cut them down at three years, to about six inches, in order to form stools, which in about ten years are cut, having produced several stems from each. Some persons have cut seedling trees down at this age to three inches for timber, leaving only one strong shoot to grow from each stool; and thus finer trees are frequently (or rather certainly) produced, than from seedlings not cut down.

The distances of the timber-plants, may be from twenty-five to thirty-five feet, according to the soil, or opinion of the planter. If no view to underwood, the above open planting may be made close, by setting first the principals (which should be fine plants), and then filling up with others that are worse, to within about eight or nine feet of one another. They will at this distance come to fair timber, or may be thinned at pleasure; and even among these, a small crop of underwood might be had which would shelter the timber-plants, and help to draw them up straight.

As to little plantations, of thickets, coppices, clumps, and rows of trees, they are to be set close according to their nature, and the particular view the planter has, who will take care to consider the usual size they attain, and their mode of growth. An advantage at home for shade or shelter, and a more distant object of sight, will make a difference. For some immediate advantage, very close planting may take place, but good trees cannot be thus expected; yet if thinned in time, a straight tall stem is thus procured, which afterwards is of great advantage.

For little clumps or groups of forest-trees (as elms), these may be planted three or four in a spot, within five or six feet of one another, and thus be easily fenced; having the air freely all round, and a good soil, such clumps produce fine timber.

Single trees of every sort grow off apace, and are more beautiful than when in the neighbourhood of others, and particularly firs, pines, larches, limes, walnuts, and chesnuts: the edible fruited chesnut is exceedingly good for timber; but the horse is only ornamental, flourishing most on high dry ground. As to rows of trees, whether single or double, when planted for a screen, they may be set about seven or eight feet asunder, upon an average, according to their nature, taking care to prune them occasionally, from too galling an interference.

Avenues are now seldom planted; but when they are, two good rows of elms, limes, chesnuts, &c. should be set at the width of the house, at full thirty feet distance in the rows: to thicken which, intermediate plants may be set; and also an inner row, to be removed when the principal trees are full grown. Avenues to prospects should be fifty or sixty feet wide.

The best season for planting the deciduous kinds of forest-trees, is toward the end of October, and for evergreen sorts, the end of March; though the soil, whether light and dry, or heavy and wet, should somewhat direct; evergreen trees being to be planted generally with safety, early in autumn, if the soil is warm; but in all cases trees should be planted in dry weather, that the mould may be loose to drop in, and lie close between the roots, which is a material thing: trees planted in rain or mists, are injured by the moisture moulding the roots.

Forest-trees for planting are generally preferred rather large, and being so, should not be taken up carelessly, but with as much of an uninjured spread of roots as possible; yet free-growing plants of about three or four feet high, promise in the end to make finer trees than those that are planted larger. Some say they are best at this size from the seed-bed; and others, to have been once planted out, having had their tap roots then cut: and generally speaking this is the case, as they have a more bushy and horizontal root.

In the act of planting, let every thing be done as for fruit-trees; *i. e.* the hole dug wide and deep, the ground well broken, or rather sifted, to lie immediately about the roots, &c. Let the trees be made fast by stakes, and litter laid about their roots to keep out frost and drought. It is of much consequence to take care that the roots (especially of evergreen trees) do not get withered before planted. Evergreens do best in a dry, but deciduous forest-trees (generally) in a moist soil, if it is not wet. Oaks, in particular, though at first they may appear to do poorly, grow well in strong moist ground, and make the best timber.

Fencing is the last thing to be considered. If trees are planted where cattle go, their stems must be protected from barking and rubbing. The common way of small posts and little rails is well known; but if large cattle are not led where the trees are, good thorns stuck round them, and tied to them, are sufficient, and indeed this might do in almost all cases. There are various ways, ordinarily known; but whatever mode is used, let it be at first well executed, and afterwards repaired in time, as often as there is need.

Whoever plants forest-trees, should take care to dress them by proper pruning, and suffering no suckers to remain about their roots. The tops should be kept equal, and not permitted to spread too much in heavy branches, but trained in a light and spiral way, always preserving the leading shoot, to encourage mounting, which is the perfection of a forest-tree. The stems of all trees designed for timber, should be constantly and timely attended to, as it is necessary to rub off buds, or to cut off the side shoots, except here and there a small one, which may serve to detain the sap to the swelling of the trunk; but branches being left on of any strength, keep the tree from mounting, and draw it crooked; and such branches, if cut off when large, occasion knots, and sometimes a decay at the part.

Plantations growing thick should be thinned in time, but not too much at once, especially in hilly situations; for those trees which remain, come suddenly to be exposed (after having been brought up under the shelter of others), and suffer much; getting crooked, stunted, and bushy, instead of having their desirable erect form, without which they are not adapted for superior uses, or agreeable to the eye.

Ornamental trees, as the crab, black cherry, mountain ash, &c. may prove profitable, as well as agreeable, here and there one amongst forest-trees, and should therefore not be omitted: the wood is good.

FORE-STAFF, or CROSS-STAFF, an instrument used at sea for taking the altitude of the sun, moon, or stars. It is called fore-staff, because the observer, in using it, turns his face towards the object; whereas in using Davis's quadrant, the back of the observer is towards the object; and hence its denomination of back-staff. See INSTRUMENTS ASTRONOMICAL.

FORESTALLING, is the buying or bargaining for any corn, cattle, or other merchandize, by the way, before it comes to any market or fair, to be sold; or by the way, as it comes from beyond the seas, or otherwise, towards any city, port, haven, or creek, of England, to the intent to sell the same at a higher price.

At the common law, all endeavours to enhance the price of any merchandize, and all practices which have an apparent tendency thereto, whether by spreading false rumours, or by purchasing things in a market before the accustomed hour, or by buying and selling again the same thing in the same market, or by any such-like devices, are highly criminal, and punishable by fine and imprisonment. 1 Haw. 234.

Several statutes have from time to time been made against these offences in general, which were repealed by 12 Geo. III. c. 71.

But though these offences are no longer combated by the statutes, they are still punishable upon indictment at the common law, by fine and imprisonment.

FORESTER, a sworn officer of the forest, appointed by the king's letters patent, to walk the forest at all hours, watch over the vert and venison; also to make attachments and true presentments of all trespasses committed within the forest.

FORFEITURE, is a punishment annexed by law, to some illegal act or negligence in the owner of lands, tenements, or hereditaments, whereby he loses all his interest therein, and they go to the party injured, as a recompense for the wrong which either he alone or the public together with him have sustained. 2 Black. 267.

The offences which induce a forfeiture of lands and tenements, are principally the following: treason, felony, misprison of treason, præmunire, drawing a weapon on a judge, striking any one in the presence of the king's court of justice, and popish recusancy, or non-observance of any certain laws enacted in restraint of papists.

By the common law, all lands of inheritance of which the offender is seised in his own right, and also all rights of entry to lands in the hands of a wrong-doer, are forfeited to the king on an attainder of high treason, although the lands are holden of another; for there is an exception in the oath of fealty, which saves the tenant's allegiance to the king; so that if he forfeits his allegiance, even the lands he held of another lord are forfeited to the king, for the lord himself cannot give of lands but upon that condition. Co. Lit. 8.

Also upon an attainder of petit treason or felony, all lands of inheritance of which the offender is seised in his own right, as also all rights of entry to lands in the hands of a wrong-doer, are forfeited to the lord of whom they are immediately holden: for this by the feudal law was deemed a breach of the tenant's oath of fealty in the highest manner; his body with which he had engaged to serve the lord being forfeited to the king, and thereby his blood corrupted, so that no person could represent him; and all personal estates, whether they are in action or possession, which the party has or is entitled to, in his own right, and not as executor or administrator to

another, are liable to such forfeiture in the following cases:

1st. Upon a conviction of treason or felony. But the lord cannot enter into the lands, holden of him upon an escheat for petit treason or felony, without a special grant, till it appears by due process that the king has had his due prerogative of the year, day, and waste. Stamf. P. C. 191.

As to forfeiture of goods and chattels, it seems agreed that all things whatever, which are comprehended under the notion of a personal estate, are liable to such forfeiture.

2nd. Upon a flight found before the coroner, on view of a dead body.

3d. Upon an acquittal of a capital felony, if the party is found to have fled. 2 Haw. 450.

4th. If a person indicted of petit larceny and acquitted is found to have fled for it, he forfeits his goods as in cases of grand larceny. 2 Haw. 451. But the party may in all cases, except that of the coroner's inquest, traverse the finding of the flight; and it seems agreed that the particulars of the goods found to be forfeited may also be traversed.

5th. Upon a presentment by the oaths of twelve men, that a person arrested for treason or felony fled from, or resisted, those who had him in custody, and was killed by them in the pursuit or scuffle. Id.

6th. If a felon waive, that is, leave any goods in his flight from those who either pursue him, or are apprehended by him so to do, he forfeits them, whether they are his own goods, or goods stolen by him; and at common law, if the owner did not pursue and appeal the felon he lost the goods for ever: but by 21 H. VIII. c. 11, for encouraging the prosecution of felons, it is provided, that if the party comes in as evidence on the indictment, and attaints the felon, he shall have a writ of restitution. 4 Inst. 134.

7th. If a man is felo de se, he forfeits his goods and chattels. 5 Co. 109.

8th. A convict within clergy forfeits all his goods, though he may be burnt in the hand; yet thereby he becomes capable of purchasing other goods. But, on burning in the hand, he ought to be immediately restored to the possession of his lands. 2 H. 388, 389.

The forfeiture upon an attainder of treason or felony shall have relation to the time of the offence for the avoiding all subsequent alienation of the lands; but to the time of conviction, or fugam fecit found, &c. only as to chattels, unless the party was killed in flying from, or resisting those who had arrested him: in which case it is said that the forfeiture shall relate to the time of the offence. Plowd. 488.

Forfeiture *in civil cases.* A forfeiture of copyhold by selling timber was relieved in equity; but the lord-keeper declared, that in case of a wilful forfeiture he would not relieve. Chan. Cas. 96. In case of a forfeiture equity can relieve, where they can give satisfaction. 1 Salk. 156.

Forfeiture *of marriage*, a writ which anciently lay against him, who by holding knight's service, and being under age, and unmarried, refused her whom the lord offered him without his disparagement, and married another. F. N. B. 141.

FORFICULA, *earwig*, an insect of the coleoptera order. The generic character is, antennæ setaceous; wing-sheaths halved; wings covered; tail forcipated. This is not a numerous genus. The forficula auricularia, or common earwig, is an insect so familiarly known, that a formal description might seem unnecessary: its structure, however, is highly curious, and its natural history well worthy of particular observation. The wings of this insect are remarkably elegant, and are convoluted beneath their small sheaths in so curious a manner that they cannot be viewed without admiration: they are very large in proportion to the animal, transparent, and slightly iridescent. The earwig flies only by night, and it is not without great difficulty that it can be made to expand its wings by day: it is even probable that they would receive injury by any long exposure to the diurnal air; the animal therefore keeps them completely covered; and indeed so unusual a circumstance is it to see them expanded, that sir Thomas Brown, in his Pseudodoxia Epidemica, has thought it necessary to confute the commonly received opinion, that the earwig is an "impennous insect."

The female earwig deposits her eggs, which are rather large for the size of the animal, of a white colour, and of an oval shape, under stones, or in any damp situation, where they may be secure from too much heat or drought. From these eggs are hatched the young larvæ, which are at first very small, but have very much the general aspect of the parent animal, except that they are of a white or whitish colour, and that the limbs of the forceps at the tip of the abdomen are not yet curved inwards. The parent insect, according to the observations of Degeer, guards and broods over her young nearly in the same manner as a hen does over her chickens; and they generally remain close to the sides, or under the abdomen of the parent, for several hours in the day. They change their skin at certain intervals during the earlier stages of their growth; and after each change acquire a darker colour and a greater degree of resemblance to the full-grown insect; till at length the wing-sheaths and wings are formed, and the animals may be considered as perfect.

The usual food of the earwig consists of decayed fruit, and other vegetable substances; and it does not seem to be naturally carnivorous, though, if kept without proper nourishment, it will, like many other animals, occasionally attack and even devour its own species.

The popular dread in which this insect is held, on a supposition of its sometimes entering the cavity of the ear, and piercing the tympanum, is considered by some as problematical, though we believe there are instances of earwigs, which naturally creep into holes and apertures of every kind, having accidentally taken shelter in the ears of persons asleep, and occasioning great pain. The best means of expelling them, we have heard, is to drop a small quantity of brandy or other spirit into the ear.

FORGE, properly signifies a small furnace, in which smiths and other artificers of iron or steel, &c. heat their metals red-hot, in order to soften and render them more malleable and manageable on the anvil.

The forge used by the several operators in iron is very simple: we shall instance that of the blacksmiths,

to which all the rest are reducible, the construction of which is as follows. The hearth or fireplace of the forge is to be built up from your floor with brick, about two feet and a half, or sometimes more, according to the purpose you design to forge for: if your forge is intended for heavy work, your hearth must lie lower than it need be for light work: the forge may be of what breadth is thought convenient. It may be built with hollow arches underneath, to set several things out of the way: the back of it is built upright to the top of the ceiling, and inclosed over the fireplace with a hovel, which ends in a chimney to carry away the smoke. In the back of the forge, against the fireplace, is fixed a thick iron plate, with a taper pipe in it, about five inches long, which pipe comes through the back of the forge. Into this taper pipe is placed the nose or pipe of the bellows: the office of this is to preserve the pipe of the bellows and the back of the forge about the fireplace, from burning. Right before the back is placed, at about two feet distance, the trough, which reaches commonly the whole breadth of the forge, and is as broad as is thought necessary. The bellows is placed behind the back of the forge, having one of its boards so fixed, that it can neither move upwards nor downwards. At the ear of the lower board is fastened a rope or chain, which reaches up to the rocker, and is fastened there to the further end of the handle. This handle is fastened across a rock-staff, which moves between two cheeks upon the centre pins, in two sockets; so that by drawing down this handle the moving board of the bellows rises; and by a considerable weight set on the top of its upper board, sinks down again, and by this agitation performs the office of a pair of bellows.

Forge is also used for a large furnace, in which iron ore, taken out of the mine, is melted down; or it is more properly applied to another kind of furnace, where the iron ore, melted down and separated in a former furnace, and then cast into sows and pigs, is heated and fused over again, and beaten afterwards with large hammers, and thus rendered more soft, pure, ductile, and fit for use.

Of these there are two kinds: the first is called the finery, where the pigs are worked into gross iron, and prepared for the second, which is called the chafery, where it is further wrought into bars fit for use.

FORGERY, is where a person counterfeits the signature of another with intent to defraud, which by the law of England is made a capital felony.

A receipt to a cash memorandum is not a receipt on acquittance for the payment of money within 2 Geo. II. c. 25, against forgery.

Forgery may be committed by making a mark in the name of another person. It may also be committed in the name of a person who had never had existence. And it may be committed of an instrument, though such an instrument as the one forged does not exist either in law or fact.

Indorsing a real bill of exchange with a fictitious name is forgery; although the use of a fictious name was not essential to the negotiation.

A forged bank-note (although the word pounds is omitted in the body of it), and there is no water-mark in the paper, is a counterfeit note for the payment of money.

Altering an entry of money received, made by a cashier of the bank, in the bank-book of a person keeping cash there, by prefixing a figure to increase the amount of the sum received, is forging a receipt for money.

A receipt indorsed on a bill of exchange in a fictitious name is forgery, although such name does not purport to be the name of any particular person.

If a person who has for many years been known by a name which was not his own, and afterwards assume his real name, in that name draws a bill of exchange, he will not be guilty of forgery, although such bill was drawn for fraudulent purposes.

If any person shall falsely make, forge, or counterfeit, or cause or procure to be falsely made, forged, or counterfeited, or willingly aid or assist in the false making or counterfeiting, any deed, will, bond, writing obligatory, bill of exchange, promissory note for payment of money, acquittance, or receipt, either for money or goods, with intent to defraud any person; or shall utter or publish the same as true, knowing the same to be false, forged, or counterfeited, he shall be guilty of felony without benefit of clergy; but not to work corruption of blood, or disherison of heirs. 2 Geo. II. c. 25.

Forging or imitating stamps to defraud the revenue is forgery by the several stamp acts; and the receiving of them is made single felony, punishable with seven years transportation. 12 Geo. III. c. 48.

FORGING, in smithery, the beating or hammering iron on the anvil, after having first made it red-hot in the forge, in order to extend it into various forms, and fashion it into works.

There are two ways of forging and hammering iron; one is by the force of the hand, in which there are usually several persons employed, one of them turning the iron and hammering likewise, and the rest only hammering. The other way is by the force of a water-mill, which raises and works several huge hammers beyond the force of man; under the strokes of which the workmen present large lumps or pieces of iron, which are sustained at one end by the anvils, and at the other by iron chains fastened to the ceiling of the forge.

This last way of forging is only used in the largest works, as anchors for ships, &c. which usually weigh several thousand pounds. For the lighter works, a single man serves to hold, heat, and turn with one hand, while he hammers with the other.

Each purpose the work is designed for requires its proper heat; for if it is too cold, it will not feel the weight of the hammer, as the smiths call it, when it will not batter under the hammer; and if it is too hot, it will redsear, that is, break or crack under the hammer.

The several degrees of heats the smiths give their irons, are, first, a blood-red heat; secondly, a white flame heat; and, thirdly, a sparkling or welding heat.

FORISFAMILIARI. A son is properly said to be forisfamiliari when he accepts of his father's part of his lands, and is contented with it in the life-time of his father, so that he cannot claim any more.

FORM, *printer's*, an assemblage of letters, words and lines, ranged in order, and so disposed into pages by the compositor; from which, by means of ink and a press, the printed sheets are drawn. Every form is inclosed in an iron chase, wherein it is firmly locked by a number

of pieces of wood; some long and narrow, and others of the form of wedges. There are two forms required for every sheet, one for each side; and each form consists of more or fewer pages, according to the size of the book. See PRINTING.

FORM *of a series*, in algebra, that affection of an undeterminate series, which arises from the different values of the indices of the unknown quantity.

FORM, is required in law proceedings, otherwise the law would be no art; but it ought not to be used to ensnare or entrap. Hob. 232. The formal part of the law, or method of proceeding, cannot be altered but by parliament: for if once those outworks were demolished, there would be an inlet to all manner of innovation in the body of the law itself. 1 Black. 142.

FORMA PAUPERIS, is when any person has cause of suit, and is so poor that he cannot support the usual charges of suing at law or in equity. In this case, upon his making oath that he is not worth five pounds his debts being paid, and bringing a certificate from some lawyer that he has just cause of suit, the judge admits him to sue in forma pauperis, that is, without paying fees to counsellor, attorneys, or clerk; and he shall have original writs and subpœnas gratis. 11 H. VII. c. 12.

And he shall when plaintiff be excused from costs, but shall suffer other punishment at the discretion of the judge. And it was formerly usual to give such paupers, if nonsuited, their election either to be whipped or pay the costs, though the practice is now disused. 3 Black. 400.

It seems agreed that a pauper may recover costs, though he pay none; for although the counsel and clerks are bound to give their labour to him, yet they are not bound to give it to his antagonist. Id.

FORMEDON, in law, a writ that lies for a person who has a right to lands or tenements, by virtue of any entail, arising from the statute of Westm. 2 Ch. II.

This writ is of three kinds, viz. a descender, remainder, and reverter. Formedon in descender lies where a tenant entail infeoffs a stranger, or is disseised and dies, the heir may bring this writ to recover the land. Formedon in remainder lies where a man gives lands, &c. to a person in tail, and for default of issue of his body, the remainder to another in tail: here if the tenant in tail dies without issue, and a stranger abates and enters into the land, he in remainder shall have this writ. Formedon in reverter lies where lands are entailed on certain persons and their issue, with remainder over for want of issue, and on that remainder failing, then to revert to the donor and his heirs: in this case, if the tenant in tail dies without issue, and also he in remainder, the donor and his heirs, to whom the reversion returns, may have this writ for the recovery of the estate, though the same be aliened, &c. Writs of formedon are now scarcely ever brought, the title to lands being commonly tried upon an ejectment.

FORMIC ACID, in chemistry, an acid that exists abundantly in the formica rufa, or red ant. The existence of this acid was first made known by Mr. Ray, in a correspondence with Dr. Hulse. The doctor informed him that these insects, when irritated, give out a clear liquid, which tinges blue flowers red: a fact which had been observed by others. Hence it was found to be an acid, which was obtained by bruising the insects, by distilling them, and by infusing them in water. The French chemists obtained the acid by bruising ants, and macerating them in alcohol. When the alcohol was distilled over, an acid liquor remained, which saturated with lime, mixed with sulphuric acid, and distilled, yielded a liquid that possessed all the properties of acetic acid. This acid was formerly considered as possessing peculiar properties, and then denominated formic acid; but it has lately been ascertained to consist of a mixture of acetic and malic acids.

FORMICA, *ant*, an insect of the hymenoptera class. The generic character is, head large, with diffracted filiform antennæ; mouth with large jaws, and four unequal feelers; thorax narrowed behind, and furnished with an upright scale; abdomen subglobose; males and females winged; neutrals apterous; females and neutrals furnished with a concealed sting. According to Linnæus there are 18 species. The insects of this genus live in large societies, somewhat in the manner of bees and wasps, and are like them divided into males, females, and neutrals, which latter constitute the great or general assortment, and appear to conduct the business of the nest, which is usually placed at a small distance from the surface in some slight elevation either prepared by the insects themselves, or previously formed by some other animals, as moles, &c. They feed both on animal and vegetable substances, devouring the smaller kinds of insects, caterpillars, &c. as well as fruits of different kinds. They are particularly attracted by sweets; and for this reason they ascend such trees as are infested with aphides, in order to obtain the saccharine substance discharged by those animals; and hence seems to have arisen the idea of their enmity against the genus aphis. Some species of ants are furnished with a sting, while others are destitute of that part.

The largest of the European ants is the formica herculanea, or great wood-ant, of a chesnut colour, with the abdomen measuring two lines or more in length. This species is chiefly found in dry woods of pine or fir, where it inhabits a large conical nest or hillock, composed of dry vegetable fragments, chiefly of fir-leaves: the nest is internally distributed into several paths or tubes, converging towards the central part, and opening externally: in the middle or centre reside the young, or larvæ, which are nursed by the neutral ants, and are occasionally brought to the surface, in order to be more within the influence of the air and sunshine for a certain time, after which they are again conveyed to the bottom or centre. When full-grown, they envelop themselves in oval, white, silken cases, in which they undergo their change into chrysalis, and at length emerge in their complete form. The males and females are winged, and the females are much larger than the males.

The common or black ant, formica nigra Lin. is a well-known inhabitant of our fields and gardens, residing in great numbers beneath mole-hills and other elevated spots. It is of a brownish-black colour, and of a glossy or polished surface. The eggs of this species are deposited early in the spring, and are extremely small, and of a white colour. From these are hatched the larvæ, which are of a thickish form, destitute of legs, and somewhat resemble in miniature the maggots of wasps and bees. They are carefully nourished by the neutral or labouring ants till they are arrived at their full growth, when they enclose themselves in smooth, oval, pale-yel-

low, silken webs or cases, in which state they are popularly known by the mistaken title of ant-eggs; the real eggs, as before observed, being white, and extremely small. It is generally in the months of June and July that the larvæ thus enclose themselves. The chrysalis, if taken out of its silken case, is of a white colour, and exhibits all the limbs of the future animal in an imperfect or contracted state. During the time of their remaining as chrysalis, the neutral ants attend them with the same care as when in their larva state, frequently shifting their situation, and placing them at greater or smaller elevations, according to the different state of the atmosphere. This care of the ants in conveying their pupæ from place to place, seems to have been often mistaken for a sedulous industry in collecting grains of wheat, which the pupæ, on a cursory review much resemble.

About the beginning of August the males and females may be observed in the nests: these differ from the neutrals in being furnished with wings, and the female is far larger than the male, the body equalling in size that of the common window-fly, and the upper wings being very long and large. At this time of the year the males and females emigrate in vast numbers; sometimes flying at a considerable height, and sometimes creeping along the surface. It is not uncommon to see them enter houses at this period, attracted by sweets in particular, either moist or dry. After the breeding season the males live but a very short time, and the females return to their nests in order to deposit their eggs. During the winter this species, like the rest of the European ants, remains in a state of torpor, without laying up provisions for that season, as erroneously supposed; and during the spring emerges from its concealment, and recommences its labours.

Ants feed both on animal and vegetable substances of various kinds. Their addiction to animal substances is often turned to good account by anatomists, who, when they wish to obtain the skeleton of any animal too small or delicate to admit of being prepared the usual way, dispose the animal in a proper position in a small box, with perforations in the lid, and deposit it in a large ant-hill; in consequence of which, after a certain space, the whole of the softer parts are eaten away by these insects, and the skeleton remains in its proper position. It is thus that very elegant skeletons of frogs, snakes, &c. may be obtained.

This addiction to animal food in the insects of the genus formica can hardly be said to be productive of any mischief in the European regions; but in various parts of America and the West Indian islands the ravages committed by ants are incredible. One of the chief of these destroyers is the formica omnivora of Linnæus, a very small species, of a brown or chesnut colour: it is extremely voracious, attacking every animal substance to which it can gain access. It occurs in various parts of Africa as well as in America and in the West Indies; and it is said to be so numerous in some districts, that a deer, hog, &c. being killed, and left on the ground by night, will by the next morning have the flesh entirely cleared from the bones, and be reduced to a complete skeleton.

The formica rufa is black; thorax compressed; and with legs ferruginous. See Plate LX. Nat. Hist. fig. 208.

FORRAGE, in the military art, denotes hay, oats, barley, wheat, grass, clover, &c. brought into the cam by the troopers for the sustenance of their horses.

FORSKOHLEA, a genus of the pentagynia order, in the decandria class of plants. The calyx is pentaphyllous, and longer than the corolla. There are ten petals spatulated, *i. e.* roundish before, with a linear base. There are three species, two of them annuals, natives of Egypt, the Cape, and Teneriffe.

FORSTERA, a genus of the triandria order, in the gynandria class of plants. The perianthium is double; the exterior one beneath, three-leaved; the interior one above, and six-cleft; the corolla tubular. There is one species, an herbaceous plant of New Zealand.

FORT, in the military art, a small fortified place, environed on all sides with a moat, rampart, and parapet. Its use is to secure some high ground, or the passage of a river, to make good an advantageous post, to defend the lines and quarters of a siege, &c.

Forts are made of different figures and extents, according as the ground requires. Some are fortified with bastions, others with demi-bastions. Some again are in form of a square, others of a pentagon. A fort differs from a citadel, as this last is built to command some town. See FORTIFICATION.

FORTIFICATION, may be defined the science of military architecture; and when applied to a city, town, or other place, it consists in the art of putting any of these in such a posture of preparation, by means of ramparts, parapets, ditches, and outworks, that each individual part defends, and is defended by, some other parts, so that a small number of men can hold out for a considerable time against a multitude.

When scattered families, abandoning a wandering and pastoral life, settled in communities for mutual support, and built towns for common advantage, it became necessary to think of the means of defence: the trunks and branches of trees, and then walls and ditches, rudely constructed, were accordingly the first elements of fortification; and as the art of war was also in its infancy, these were sufficient to defeat hasty attacks, and prevent sudden incursions. At length offensive weapons were invented; and as the assailants had thus acquired a decided advantage, it became necessary to employ new means to frustrate them. Loop-holes, through which the arrows of the besieged might be directed with almost unerring certainty, were accordingly recurred to; and at length square towers were made to project from the walls, so as to enable the men placed within them to scour the ditches and defend the walls. In the progress of improvement the outer line of these quadrangular masses was made to assume a curvilinear direction; and at the present day there still remain numerous traces of this mode in all the ancient castles in the kingdom.

But as the science advanced towards perfection new advantages were obtained; and instead of presenting a large semicircular portion of masonry to the enemy, an angle only was projected, and such a fortunate disposition of the works thereby produced, that no part could be attacked with impunity. In process of time ramparts were added; and the ancient towers, which had been changed into bastions, were provided with ravelins, horn-works, and outworks of all kinds, so as to resist the violence of cannon and mortar batteries; and defy, at least

for a time, the efforts of the besiegers, provided with all the various implements of modern warfare.

Fortification is either regular or irregular. The regular is that built in a polygon, the sides and angles of which are all equal, being commonly about a musket-shot from each other. Irregular fortification, on the contrary, is where the sides and angles are not uniform, equidistant, or equal.

I. Of regular Fortification.

Authors in general agree as to the form, but they differ in respect to the construction of the parts. The chief of those who have written on this art, are Pagan, Blondel, Vauban, Coehorn, Scheiter, and Muller: in addition to these the names of Robins, Belidor, Folard, le Blond, marshal Saxe, Tielke, and Belair, ought also to be enumerated, as they have greatly contributed to the general knowledge of the science.

It must be constantly recollected by every engineer, that his views are not to be confined to the mere art of fortification. He must be able to take advantage of natural strength and position. Chains of mountains and streams of water, together with the influence of climate, should constitute a part of the natural system to which he should direct his application.

According to count Pagan, fortification consists of three different sorts, viz. the great, the mean, and the little, the principal dimensions of which are contained in the following Table.

	The Great Fortification.		The Mean.		The Little.	
	For Squares.	For all other Polygons	For Squares	For all other Polygons	For Squares	For all other Polygons
Exterior side	200	200	180	180	160	160
The perpendicular	27	30	24	30	21	30
The face -	60	60	55	55	45	50
The flank -	22	24-2	19-1	24	18-3	23-2
The curtin -	73-2	70-5	63-4	60-4	63-5	50-4
The line of defence	141-4	141-2	126-1	126-5	115-5	112-3

Blondel fortifies within the given polygon: he establishes two sorts of fortification; the great one, whose exterior side is 200 toises, and the lesser one, 170; because he will not have the line of defence exceed 140 toises, which is the greatest musket-shot, nor less than 120 toises, not to increase the number of bastions. He begins by the diminishing angle, which may be found by taking 90 degrees from the angle of the polygon, and by adding 15 degrees to the third of the remainder.

Vauban's method is divided into little, mean, and great; the little is chiefly used in the construction of citadels; the mean, in that of all sorts of towns; and the great, in particular cases only.

	Forts.						Little.				Mean.		Great.	
Side of polygon	80	90	100	110	120	130	140	150	160	170	180	190	200	260
Perpendicular	10	11	12½	14	15	16	20	21	23	25	30	31	25	22
Faces bastion	22	5	28	30	33	35	40	42	45	47	50	53	55	60
Cap. of ravel.	25	28	30	35	38	40	45	50	50	52	55	55	60	50

In the first vertical column are the numbers expressing the lengths of the exterior sides from 80 to 260.

In the second, the perpendiculars answering to these sides.

In the third, the lengths of the faces of the bastions; and in the fourth, the lengths of the capitals of the ravelins.

Belidor's method is divided also into little, mean, and great; and in all three the exterior side is 200 toises; the perpendicular of the little is 50, that of the mean 55, and the great 40; the faces of the first 70, the second 70, and the third 55 toises.

Scheiter's method is divided into the great, mean, and small sort. The exterior side of the polygon for the great sort is 200 toises, the mean sort 180, and the small 160. The line of defence in the first is 140 to toises, the second 130, and the third 120. This line is always razant. All the other lines are fixed at the same length for all poly-

gons, whose structure chiefly depends upon the knowledge of the exterior side, of the capital, or of the flanked angle, the rest being easily finished.

TABLE of CAPITALS and FLANKED ANGLES.

Polygons.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
The flanked angles in the 3 sorts of fortification	deg. 64	76	84	90	95	97	99	101	103
Capital for the great sort	toise 46	49	51	52	53	54½	56½	58	59
Capital for the mean sort	42	44½	46½	48½	50	51	52½	54	54
Capital for the small sort	39	41½	42½	45	46	47½	48½	50	50½

Errard, of Bois-le-Duc, who was employed by Henry IV. and was the first that laid down rules in France respecting the best method of fortifying a place so as to cover its flank, constructs that flank perpendicular to the face of the bastion; but by endeavouring to cover it effectually, he makes the gorges too exiguous, the embrazures too oblique, and leaves the ditch almost defenceless.

The chevalier de Ville, who succeeded Errard, draws the flank line perpendicular to the curtin; but here again the embrasures are too oblique, especially in the polygons, and the ditch is necessarily ill guarded. This engineer's method of fortifying is styled by most authors, the French method. His favourite maxim is, to make the flank angle straight, and the flank equal to the demigorge.

Count Pagan makes the flank perpendicular to the line of defence, which method seems to agree perfectly with this maxim, because by that means the flank so raised covers as much as possible the face of the opposite bastion; but notwithstanding this apparent advantage, the flank becomes too small, and is too much exposed to the enemy's batteries. This engineer acquired great reputation during the several sieges which he assisted in conducting under Louis XIII. His system has been improved upon by Alain Marrison Mallet, and his construction in fortification is to this day esteemed the most perfect. It differs very little from marshal Vauban's first system. Count Pagan has pointed out the method of building casements in a manner peculiar to himself.

Marshal Vauban has judiciously steered between these different methods. He has drawn his flank in such a manner, that it does not stand too much exposed, nor does its collateral line of defence extend too far from the direct line of defence. He has effected this by lengthening out his flank, and giving it a circular form.

It cannot be disputed that large and extensive flanks and demigorges are superior to narrow and confined ones. The more capacious the flank is, the better calculated will it prove for the disposition of a formidable train of artillery. From this conviction many writers, in their proposed system of fortification, have added a second flank, in order to augment the line of defence; but they did not foresee that this second flank is not only incapable of covering the face of the opposed bastion, except in a very oblique and insecure direction; but that the right flank or the flank of the bastion, is thereby more exposed to the enemy's batteries, which, it must be acknowledged on all sides, is a great fault.

The prevailing system of the present day is, to make the flanks of the bastion as wide as possible, without having recourse to a second flank, unless it be absolutely necessary. Those gorges are likewise best which are most capacious, because they afford space and ground in the bastion for the construction of entrenchments within, should the enemy have effected a practicable breach.

All parts of a fortification which stand exposed to the immediate attacks of a besieging enemy, must be strong enough to bear the boldest attempts, and the most vigorous impressions. This is a self-evident maxim, because it must be manifest to the most common understanding, that works are erected round a place for the specific purpose of preventing an enemy from getting possession of it. It consequently follows, that flanked angles are extremely defective when they are too acute, since their points may be easily flanked and destroyed by the besiegers' cannon.

The Dutch construct at sixty degrees; but according to Vauban's method, no work should be under seventy-five degrees, unless circumstances and situation should particularly require it.

The diagram annexed, together with the explanation that follows, will convey an idea of M. Vauban's method, in respect to the fortification of towns. See Plate LVI. Farriery, &c.

Inscribe in a circle a polygon of as many sides as the fortification is designed to have fronts; let AB, fig. 9, be one of the sides of half an hexagon, which bisect by the perpendicular CD; divide half of it AC into nine equal parts, and one of these into ten others; then these divisions will serve as a scale to construct all the parts of the fortification, and each of them supposed to be a toise or fathom, that is, six French feet; and therefore the whole side AB is supposed to be 180 toises. As the dividing a line into so many equal parts is troublesome and tedious, it is more convenient to have a scale of equal parts, by which the works may be constructed.

If therefore, in this case, the radius is taken equal to 180 toises, and the circle described with that radius being divided into six equal parts, or the radius being carried six times round, you will have an hexagon inscribed; AB being bisected by the perpendicular CD as before,

set off 30 toises from C to D, and draw the indifinite lines ADG, BDF; in which take the parts AE, BH, each equal to 50 toises; from the centre E describe an arc through the point H, meeting AD in G, and from the centre H describe an arc through the point E, meeting BD in F; or, which is the same, make each of the lines EG, HF, equal to the distance EH; then the lines joining the points A, E, F, G, H, B, will be the principal or outline of the front.

If the same construction be performed on the other sides of the polygon, you will have the principal or outline of the whole fortification. If, with a radius of 20 toises, there be described circular arcs from the angular points B, A, M, T, and lines are drawn from the opposite angles E, H, &c. so as to touch these arcs, their parts *ab*, *bc*, &c. together with these arcs, will present the outline of the ditch.

Definitions.

1. The part FEALN is called the bastion.
2. AE, AL, the faces of the bastion.
3. EF, LN, the flanks.
4. FG, the curtin.
5. FN, the gorge of the bastion.
6. AG, BF, the lines of defence.
7. AB, the exterior side of the polygon.
8. CD, the perpendicular.
9. Any line which divides a work into two equal parts is called the capital of that work.
10. *a*, *b*, *c*, the counterscarp of the ditch.
11. A, M, the flanked angles.
12. H, E, L, the angles of the shoulder, or shoulder only.
13. G, F, N, the angles of the flank.
14. Any angle whose point turns from the place is called saliant angle, such as A, M: and any angle whose point turns towards the place, re-entering angle, such as *b*, F, N.
15. If there be drawn two lines parallel to the principal or outline, the one at 3 toises distance, and the other at 8 from it, then the space *yx* included between the principal one and that farthest distant is called the rampart.

And the space *x*, contained by the principal line and that near to it, and which is generally stained black, is called the parapet.

16. There is a fine line drawn within four feet of the parapet, which expresses a step called banquette.

All works have a parapet of three toises thick, and a rampart of from 8 to 10, besides their slopes. The rampart is elevated more or less above the level of the place, from 10 to 20 feet, according to the nature of the ground, and the particular constructions of engineers.

The parapet is a part of the rampart elevated from 6 to $7\frac{1}{2}$ feet above the rest, in order to cover the troops which are drawn up there from the fire of the enemy in a siege; and the banquette is two or three feet higher than the rampart, or about four feet lower than the parapet; so that when the troops stand upon it, they may just be able to fire over the parapet.

17. The body of the place is all that which is contained within this first rampart; for which reason it is often said to construct the body of the place: which means, properly, the construction of the bastions and curtins.

18. All the works which are constructed beyond the ditch, before the body of the place, are called outworks.

II. Of irregular Fortification.

The most essential principle in fortification consists in making all the fronts equally strong, so that the enemy may find no particular advantage in attacking either of the sides. But this can only occur in a regular work, situated in a plain, or even ground; consequently there are but few places which are not irregular: and the great art here is, to remedy the defects and inconveniences occasioned by this circumstance.

If the situation to be fortified is an old town, inclosed by a wall or rampart, the engineer ought to consider well all the different circumstances of the figure, position, and nature of the ground, and to regulate his plan accordingly, so as to avoid as many disadvantages, on one hand, and to obtain as many advantages, on the other, as possible. If there is a rampart without towers, it must be decided whether bastions ought not to be added, and revelins and counter-guards constructed. Special care must be taken to make all the sides of the polygon nearly equal, and that the length of the lines of defence do not exceed the reach of musket-shot. Wherever the sides are inaccessible, either on account of a precipice, or marshy ground, they may be made much larger than those which are easy of access.

If the place to be fortified is new, and the situation will not admit of a regular construction, particular care must be taken to choose such a spot of ground as is most advantageous. All hills, or rising grounds, should be avoided, as these might command some parts of the works; marshes, because such situations are unwholesome, and lakes and standing waters for the same reason, except they can be rendered navigable.

Places built on mountains or rocks should never be large; for their use is generally to guard passes or inlets into a country, and it is difficult to provide for a large garrison under such circumstances. When fortifications are to be placed in the neighbourhood of the sea, for the purposes of protecting trade, the first thing to be considered is their situation, which ought to afford a good harbour for shipping. When M. Vauban fortified near rivers, he always made the exterior side next to the water much longer than any of the others; for as that part is not so liable to be attacked, great and manifest advantages were of course derived from this circumstance.

To illustrate this method of M. Vauban's, we shall give the plan of Hunninghen. That place was built for the sake of having a bridge over the Rhine, for which reason he made it only a pentagon; the side AB (fig. 10) next to the river is 200 toises, and each of the others but 180.

About the space *abc*, which lies before the front AB, is a stone wall: and the passages, are shut up with sluices, to retain the water in the ditches in dry seasons; and to prevent an enemy from destroying the sluice near the point *c*, whereby the water would run out and leave the ditches dry, the redoubt *y* was built in the little island hard by, in order to cover that sluice; without which precaution the place might be insulated from the river side, where the water is shallow in dry seasons.

The hornwork K, beyond the Rhine, was built to cov-

er the bridge; but as this work cannot be well defended across the river, the hornwork H was made to support the other.

Before finishing the description of this plan, we shall show how to find the long side AB. After having inscribed the two sides GE, GF, in a circle, draw the diameter CD, so as to be equally distant from the line joining the points EF that is parallel to it. On this diameter set off 100 toises on each side of the centre; from these points draw two indefinite perpendiculars to the diameter; then if from the points, EF, as centres, two arcs are described with a radius of 180 toises, their intersections A and B, with the said perpendiculars, will determine the long side AB, as likewise the other two FB and EA. In like manner may be found the long or short side of any polygon whatsoever.

When a place near a river is to be fortified for the safety of commerce, particular care should be taken in leaving a good space between the houses and the waterside, to have a quay or landing-place for goods brought by water; it should also be contrived to have proper places for ships and boats to lie secure in stormy weather, and in time of a siege; and as water-carriage is very advantageous for transporting goods from one place to another, as likewise for bringing the necessary materials, not only for building the fortifications, but also the place itself, the expenses will be lessened considerably when this convenience can be had; for which reason places should never be built any where but near rivers, lakes, or the sea, excepting in extraordinary cases, where it cannot be avoided.

The principal maxims of fortification are these, viz.

1. That every part of the works be seen and defended by other parts, so that the enemy cannot lodge any where without being exposed to the fire of the place.

2. A fortress should command all places round it; and therefore all the outworks should be lower than the body of the place.

3. The works furthest from the centre should always be open to those that are nearer.

4. The defence of every part should always be within the reach of musket-shot, that is, from 120 to 150 fathoms, so as to be defended both by ordnance and small fire-arms; for if it is only defended by cannon, the enemy may dismount them by the superiority of their own, and then the defence will be destroyed at once; whereas, when a work is likewise defended by small-arms, if the one is destroyed, the other will still subsist.

5. All the defences should be as nearly direct as possible; for it has been found by experience, that the soldiers are too apt to fire directly before them, without troubling themselves whether they do execution or not.

6. A fortification should be equally strong on all sides; otherwise the enemy will attack it in the weakest part, whereby its strength will become useless.

7. The more acute the angle at the centre is, the stronger will be the place.

8. In great places dry ditches are preferable to those filled with water, because sallies, retreats, succours, &c. are necessary; but, in small fortresses, wet ditches, that can be drained, are the best, as standing in need of no sallies

Field-Fortification is the art of constructing all kinds of temporary works in the field, such as redoubts, field-forts, star-forts, triangular and square forts, heads of bridges, and various sorts of lines, &c. An army entrenched, or fortified in the field, produces, in many respects, the same effect as a fortress; for it covers a country, supplies the want of numbers, stops a superior enemy, or at least obliges him to engage at a disadvantage.

The knowledge of a field-engineer being founded on the principles of fortification, it must be allowed, that the art of fortifying is as necessary to an army in the field as in fortified places; and though the maxims are nearly the same in both, yet the manner of applying and executing them with judgment, is very different.

The materials used in the field are such as can be readily obtained, viz. sand-bags, earth, and fascines ten feet long and one foot thick, which are fastened to the parapet, by means of five pickets driven obliquely into the bank.

When wood cannot be obtained for the fascines, the parapet must be clothed with turf, four inches thick, and a foot and a half square.

The palisades for fortifying the ditch ought to be nine or ten feet long and six inches thick.

The beams belonging to chevaux-de-frize should be twelve feet long, and six inches broad; the spokes seven feet long, four inches thick, and six inches distant from each other.

Gabions must be three or four feet high, and two or three feet in diameter.

FORTIN, Fortlet, or *field-fort*, a sconce or little fort, whose flanked angles are generally distant from one another 120 fathoms.

FORTS, *vitrified*, a very singular kind of structures found in the Highlands and northern parts of Scotland, in which the walls have the appearance of being melted into a solid mass, so as to resemble the lava of a volcano, for which indeed they have been taken by several persons who have visited them.

These walls were taken notice of by Mr. Williams, an engineer, who wrote a treatise on the subject, and was the first who supposed them to be the works of art; other naturalists having attributed them to a volcanic origin. These works are commonly situated on the tops of small hills, commanding an extensive view of the adjacent valley or low country. The area on the summit, varying, as is supposed, according to the number of cattle the proprietor had to protect, or the dependants he was obliged to accommodate, is surrounded with a high and strong wall, of which the stones are melted, most of them entirely; while others, in which the fusion has not been so complete, are sunk in the vitrified matter in such a manner as to be quite inclosed with it; and in some places the fusion has been so perfect, that the ruins appear like masses of coarse glass. Mr. Williams had not only determined the walls in question to be the works of art, but has even hazarded a conjecture as to the manner in which they were constructed, and which, according to him, was as follows. Two parallel dikes of earth or soil being raised, in the direction of the intended wall, with a space between them sufficient for its thickness, the fuel was put in, and set on fire. The stones best adapted for the purpose, called the plum-pudding stone, are every where to be found in the neighbourhood. These

were laid on the fuel, and, when melted, were kept by the frame of earth from running off; and by repeating the operation, the wall was raised to a sufficient height. This opinion of the stones being thrown in without any order, is thought to be confirmed by the circumstance of there not being any where a large one to be seen, nor a stone laid in any particular direction, nor one piece which has not in some degree been affected by the fire. Mr. Williams mentions a fact tending to confirm his hypothesis, viz. of a brick-kiln situated on the declivity of an eminence, so as to be exposed to the wind, which, happening to rise briskly one time when the kiln was burning, so increased the heat, that the bricks were melted, and ran like a lava, for a considerable way down the hill.

This opinion of Mr. Williams has been embraced by several other authors; particularly Mr. Freebairn and Dr. Anderson, the latter having published two treatises upon the buildings in the Archæologia. In the same work, however, we meet with a paper by the hon. Daines Barrington, in which the author expresses quite different sentiments. He observes, that Mr. Williams and the other antiquaries, who suppose the walls in question to be the works of art, imagine that the reason of their being constructed in this manner was the ignorance of cement, which in these remote ages prevailed in Scotland: but with respect to this circumstance he says, that if one side of the wall only was heated, and that to any considerable height, the matter in fusion would in all likelihood drop down to the bottom, without operating as any cement to the loose stones thrown in amongst it. This circumstance of the walls being vitrified only on one side is indeed remarkable, and takes place in most of the forts of this kind to be met with at present; but with regard to it Mr. Barrington observes that he himself has been twice in the Highlands of Scotland, and has found very few hills of any height which were clothed with wood: the trouble therefore of carrying it up to the top of such a mountain would be very considerable.

According to Mr. Cardonnel, the largest of the vitrified forts is situated on the hill of Knockfarril, to the south of the valley of Strathpeffer, two miles west from Dingwall in Ross-shire. The inclosure is 120 feet long and 40 broad within the walls; strengthened on the outside with works at each end. The fort next in consequence to that of Knockfarril is situated on the hill of Craig-Phadric near Inverness.

Besides these fortifications, the hill of Noth affords a remarkable appearance of the same kind: of which Mr. Cordiner gives the following description, not from his own observation, but those of a gentleman of credit who visited the place. "On the top of the hill there is an oblong hollow, as I could guess, of about an English acre, covered with a fine sward of grass: in the middle towards the east end of this hollow is a large and deep well. The hollow is surrounded on all sides with a thick rampart of stones. On three sides of this rampart, from eight to twelve feet thick, is one compact body of stones and minerals which have been in a state of fusion, resembling a mixture of stone and iron-ore, all vitrified, calcined, and incorporated. On the north side, the rampart consists of broken pieces of rock, which have the appearance of having been torn to pieces by some extraordinary violence. If the calcined compact wall exists under them, it is not at present visible."

In the Phil. Trans. of the Royal Society of London for 1777, part II. is an account of Creek Faterick, there termed a volcanic hill near Inverness, in which the writer does not hesitate to pronounce this hill an extinguished volcano: and, having sent specimens of the burnt matter for the inspection of the Royal Society, the secretary subjoins a note to the paper, intimating that these specimens, having been examined by some of the members well acquainted with volcanic productions, were by them judged to be real lava.

Mr. Tytler agrees with those who think the vitrified structures to be artificial works; but he differs from Mr. Williams and others who think that they were vitrified on purpose for cementing the materials together. His reason for this is, that the number of forts that show marks of vitrification is inconsiderable when compared with those that do not. He therefore considers the vitrification as accidental, and describes the manner in which he conceives it must have been accomplished. Among other observations in confirmation of his opinion, he urges, that in the fortification on Craig-Phadric, a large portion of the outward rampart bears no marks of vitrifications. Mr. Cordiner, on the other hand, is of opinion that the vitrifications in question cannot have been the works of art, and ridicules the contrary hypothesis, though without adducing any argument against it.

Mr. Tytler concludes his dissertation with a conjecture, which indeed seems well supported, that the forts in question were constructed, not only before the Roman invasion, but before the introduction of the rites of the Druids into Britain; as "there appears no probability that the inhabitants either lived under such a government as we know to have prevailed under the influence of the Druids, or had any acquaintance with those arts which it is certain they cultivated." On a view of the disputes which have agitated the learned on this obscure subject, we can only observe, that their arguments seem to have placed it in a state of equiponderance, and that the fact remains open to the investigation of future speculators.

FOSS, in fortification, a hollow place, commonly full of water, lying between the scarp and counterscarp, below the rampart; and turning round a fortified place or a post that is to be defended.

FOSSA, in ancient English customs, was used to signify a ditch full of water, wherein women, convicted of felony, were drowned.

Foss-way, one of the four principal highways of England, that anciently led through the kingdom; supposed to be made by the Romans, having a ditch upon one side.

FOSSARII, in antiquity, a sort of officers in the Eastern church, whose business it was to inter the dead.

FOSSIL, in natural history, denotes in general all things dug out of the earth: whether they be natives thereof, as metals, stones, salts, earths, and other minerals; or extraneous, reposited in the bowels of the earth by some extraordinary means, as earthquakes, the deluge, &c. See Metal, Stone, &c.

Native fossils, according to Dr. Hill, are substances

found either buried in the earth, or lying on its surface, of a plain simple structure, and showing no signs of having contained vessels or circulating juices. These are subdivided by the same author, 1. Into fossils naturally and essentially simple. Of these some are neither inflammable, nor soluble in water; as simple earths, talcs, fibrariæ, gypsum, selenitæ, crystals, and spars: others, though uninflammable, are soluble in water; as all the simple salts: and others, on the contrary, are inflammable, but not soluble in water; as sulphur, auripigmentum, zarnich, amber, ambergris, gagates, asphaltum, ampelites, lithanthrax, naphtha, and pissasphalta. 2. The second general subdivision of fossils comprehends all such as are naturally compound, but unmetallic. Of these some are neither inflammable, nor soluble in water; as compound earths, stone, septariæ, siderochita, semipellucid gems, &c.: others are soluble in water, but not inflammable; as all the metallic salts: and, lastly, some are inflammable, but not soluble in water; as the marcasites, pyritæ, and phlogonia. 3. The third and last general division of fossils comprehends all the metallic ores; which are bodies naturally hard, remarkably heavy, and fusible in fire. Of these some are perfectly metallic, as being malleable when pure; such are gold, lead, silver, copper, iron, and tin: others are imperfectly metallic, as not being malleable even in their purest state; such are antimony, bismuth, cobalt, zinc, &c. Of all these substances the reader will find a particular description under their respective heads.

Extraneous fossils are bodies of the vegetable or animal kingdoms accidentally buried in the earth. Of the vegetable kingdom there are principally three kinds, trees or parts of them, herbaceous plants, and corals; and of the animal kingdom there are four kinds, sea-shells, the teeth or bony palates and bones of fishes, complete fishes, and the bones of land-animals. See Bones, Tree, Wood, Plant, Shell, &c. These adventitious, or extraneous fossils, thus found buried in great abundance in divers parts of the earth, have employed the curiosity of several of our latest naturalists, who have each a different system to account for the surprizing appearances of petrified sea-fishes, in places far remote from the sea, and on the tops of mountains; shells in the middle of quarries of stone; and of elephants' teeth, and bones of various animals, peculiar to the southern climates, and plants only growing in the East, found fossil in our northern and western parts.

Some will have these shells, &c. to be real stones, and stone plants, formed after the usual manner of other figured stones; of which opinion is the learned Dr. Lister. Another opinion is, that these fossil shells, with all their foreign bodies found within the earth, as bones, trees, plants, &c. were buried therein at the time of the universal deluge; and that, having been penetrated by the calcareous or siliceous matter abounding chiefly in watery places, and then in a state of solution they have been preserved entire, and sometimes petrified. Others think, that those shells, found at the tops of the highest mountains, could never have been carried thither by the waters, even of the Deluge; inasmuch as most of these aquatic animals, on account of the weight of their shells, always remain at the bottom of the water, and never move but close along the ground. They imagine, that a year's continuance of the waters of the Deluge, intermixed with the salt waters of the sea, upon the surface of the earth, might well give occasion to the production of shells of various kinds in different climates; and that the universal saltness of the water was the real cause of their resemblance to the sea-shells, as the lakes formed daily by the retention of rain or spring water produce different kinds. Others think, that the waters of the sea and the rivers, with those which fell from heaven, turned the whole surface of the earth upside down; after the same manner as the waters of the Loire, and other rivers, which roll in a sandy bottom, overturn all their sands, and even the earth itself, in their swellings and inundations; and that in this general subversion, the shells came to be interred here, fishes there, trees in another place, &c.

Dr. Woodward, in his Natural History of the Earth, pursuing and improving the hypothesis of Dr. Burnet, maintains the whole mass of earth, with every thing belonging to it, to have been so broken and dissolved at the time of the Deluge, that a new earth was then formed on the bosom of the water, consisting of different strata, or beds of terrestrial matter, ranged over each other usually according to the order of their specific gravity. By this means plants, animals, and especially fishes and shells, not yet dissolved among the rest, remained mixed and blended among the mineral and fossil matters; which preserved them, or at least assumed and retained their figures and impressions either indentedly, or in relievo.

FOTHER, or *fodder*, in mining. See Fodder.

FOTHERGILLA, a genus of the polyandria and digynia class and order. The calyx is an ament ovate; scales one-flowered; corolla calyx-form, one-petalled, five-cleft. There is one species, a tree of Caroline resembling the alder.

FOUL, in the sea-language, is used when a ship has been long untrimmed, so that the grass, weeds, or barnacles, grow to her sides under water. A rope is also foul when it is either tangled in itself, or hindered by another, so that it cannot run, or be overhawled.

Foul, imports, also, the running of one ship against another. This happens sometimes by the violence of the wind, and sometimes by the carelessness of the people on board, to ships in the same convoy, and to ships in port by means of others coming in. The damages occasioned by running foul, are of the nature of those in which both parties must bear a part. They are usually made half to fall upon the sufferer, and half upon the vessel which did the injury: but in cases where it is evidently the fault of the master of the vessel, he alone is to bear the damage.

Foul-water. A ship is said to make foul-water, when being under sail, she comes into such shoal-water, that though her keel does not touch the ground, yet it comes so near it, that the motion of water under her raises the mud from the bottom.

FOUNDATION, in architecture, is that part of a building which is under ground. See Architecture.

FOUNDER, in a general sense, the person who lays a foundation, or endows a church, school, religious-house, or other charitable institution. The founder of

a church may preserve to himself the right of patronage or presentation to the living.

Founder, also implies an artist who casts metals, in various forms, for different uses, as guns, bells, statues, printing characters, candlesticks, buckles, &c. whence they are denominated gun-founders, bell-founders, figure-founders, letter-founders, founders of small works, &c. See Foundery.

The most common implements used by the founder are, several different sized pairs of open frames, fig. 1, called flasks; two or three single-handed ladles, fig. 4; a large double-handed ladle, fig. 5; a wooden bar, fig. 6, called a striker; a flat iron rammer, fig. 7; several hand screws, fig. 8; a small trowel with a square end, fig. 9; also, a great quantity of damp loamy sand, and a small quantity of the same, which has been burnt in the furnace, and is kept dry. An exact pattern of the thing to be cast is, in most cases, to be made in wood: the workmen selects a pair of flasks, whose size is best adapted to the size of the article, sets it on a board, H, fills the under one with sand, rams it in with the rammer, fig. 7, and scrapes off the loose sand with the striker, fig. 6; he then with his trowel, fig. 9, digs out a space large enough to contain the pattern for the article (which we will in this case suppose to be a crow for a mill-stone, see Flour-mill, and Figs 2 and 3,) into this space the pattern is placed, and the sand is laid close round it, and pressed and flattened down with the trowel, so as to bury the lower half of it, as shown in the flask GI; a thin layer of dry sand is then sprinkled over it, and the other empty flask, EF, is put upon the under one, its place being determined by the points, *h i k*, in the upper flask EF, which enter the holes, *m n*, in the under flask GI; a round stick is then held upright upon the pattern, and the sand filled and rammed round it; the stick is then withdrawn, which leaves a hole, *d*, through the sand, through which the metal is to be poured. The upper flask, with the sand in it, is then lifted off, and laid upon its side, as shown in fig. 1, the dry sand making the separation at the proper place, so as to leave an impression, *o p q r*, in the upper flask, of the same size and shape as the upper half of the pattern: the sand around the pattern, *s t v w*, in the flask GI is then slightly damped, with a sponge, to make it adhere better together, and the pattern is lifted out, by screwing one or more of the screws, fig. 8, into it, leaving an impression of the lower half of the pattern, so that when the two flasks are put together again, the cavity of the whole article is formed, into which the metal is poured, through the hole *d*. For small work, the metal is melted in a furnace, blown by bellows; it has a small hole near its bottom, which is stopped with clay: when the metal is melted, this clay is poked out, and the metal which runs out, is caught in the ladle, fig. 5; when this is nearly full, it is taken up by two men (one of whom walks first, between the handles, *a b*, and another at the end, *d*,) and is distributed to the different flasks: for still smaller work, this is done by one man, who uses the ladle, fig. 4. For large works, the metal is melted in an air or draft furnace; and is conveyed to the moulds, which are in that case sunk in the ground, by little channels made in the sand, of which the floor of the foundery is composed. When the article that has been cast, is first taken out of the sand, it has a knob or runner sticking to it, in the hole, *d*, fig. 1, and has usually thin pieces sticking out from the sides of it, where the two flasks did not exactly fit: these are all taken off with a chisel, the sand is shook off the surface by knocking, and the founder's business is done.

For some articles which have one side a plain surface, as square bars, &c. no flasks are used, but the pattern is laid in a space large enough to bury it, which is made in the sand on the ground, and, the sand is banked up round it; it is then taken out as above, and the metal is poured into the cavity formed by it, till the same is full enough. The mould for large articles, as bells, boilers, cylinders, pipes, &c. are made of wet tempered loam, and dried.

Founder, in the sea-language, a ship is said to founder, when by an extraordinary leak, or by a great sea breaking in upon her, she is so filled with water, that she cannot be freed of it; so that she can neither veer nor steer, but lies like a log; and not being able to swim along, will at last sink.

FOUNDERY or *foundry*, the art of casting all sorts of metals into different forms. It likewise signifies the work-house, or smelting-hut, in which these operations are performed.

Foundery *in small works, or cutting in sand.* The sand used for casting small works is, at first, of a pretty soft, yellowish, and clammy nature; but it being necessary to strew charcoal dust in the mould, it at length becomes of a quite black colour. This sand is worked over and over, on a board, with a roller, and a sort of knife; being placed over a trough to receive it, after it is by these means sufficiently prepared.

This done, they take a wooden board of a length and breadth proportioned to the things to be cast, and putting a ledge round it, they fill it with sand, a little moistened, to make it duly cohere. Then they take out either wood or metal models of what they intend to cast, and apply them so to the mould and press them into the sand, as to leave their impression there. Along the middle of the mould is laid half a small brass-cylinder, as the chief canal for the metal to run through, when melted into the models, or patterns; and from this chief canal are placed several others, which extend to each model or pattern placed in the frame. After this frame is finished they take out the patterns, by first loosening them all round, that the sand may not give way.

Then they proceed to work the other half of the mould with the same patterns in just such another frame, only that it has pins, which, entering into holes that correspond to it in the other, make the two cavities of the pattern fall exactly on each other.

The frame thus moulded, is carried to the melter, who, after extending the chief canal of the counterpart, and adding the cross canals to the several models in both, and strewing mill-dust over them, dries them in a kind of oven for that purpose.

Both parts of the mould being dry, they are joined together by means of the pins; and to prevent their giving way, on account of the melted metal passing through the chief cylindrical canal, they are screwed or wedged up like a kind of press.

While the moulds are thus preparing, the metal is fus-

ing in a crucible of a size proportioned to the quantity of metal intended to be cast.

FOUNDERY *of statues.* See BRONZE and STATUE.

FOUNDERY OF BELLS. The metal, it is to be observed, is different for bells, from what it is for statues; there being no tin in the statue-metal: but there is a fifth, and sometimes more, in the bell metal.

The dimensions of the core, and the wax, for bells, (if a ring of bells especially) are not left to chance, but must be measured on a scale, which gives the height, aperture, and thickness necessary for the several tones required.

It is on the wax that the several mouldings and other ornaments are formed to be represented in relievo, on the outside of the bell.

The business of bell-foundry is reducible to three particulars. 1. The proportion of a bell. 2. The forming of the mould; and, 3. The melting of the metal.

The proportions of our bells differ much from those of the Chinese; in ours the modern proportions are to make the diameter fifteen times the thickness of the brim, and twelve times in height.

There are two kinds of proportions, viz. the simple and the relative; the former are those proportions only that are between the several parts of a bell. to render it sonorous; the relative proportions establish a requisite harmony between several bells.

The particulars necessary for making the mould of a bell, are, 1. The earth: the most cohesive is the best: it must be well ground and sifted, to prevent any chinks. 2. Brick-stone; which must be used for the mine, mould, or core, and for the furnace. 3. Horse-dung, hair, and hemp, mixed with the earth, to render the cement more binding. 4. The wax for inscriptions, coats of arms, &c. 5. The tallow equally mixed with the wax, in order to put a slight lay of it upon the outer mould, before any letters are applied to it. 6. The coals to dry the mould.

For making the mould, they have a scaffold consisting of four boards, ranged upon tressels. Upon this, they carry the earth, grossly diluted, to mix it with horse-dung, beating the whole with a large spatula.

The compasses of construction is the chief instrument for making the mould, which consists of two different legs joined by a third piece. And last of all, the founders shelves on which are the engravings of the letters, cartridges, coats of arms, &c.

They first dig a hole, of a sufficient depth to contain the mould of the bell, together with the case or cannon, under-ground; and about six inches lower than the terreplain, where the work is performed. The whole must be wide enough for a free passage between the mould and walls of the hole; or between one mould and another, when several bells are to be cast. At the centre of the hole is a stake erected, that is strongly fastened in the ground. This supports an iron peg, on which the pivot of the second branch of the compasses turns. The stake is encompassed with a solid brick work, perfectly round, about half a foot high, and of the proposed bell's diameter. This they call a mill-stone. The parts of the mould are the core, the model of the bell, and the shell. When the outer surface of the core is formed, they begin to raise the core, which is made of bricks that are laid in courses of equal height upon a lay of plain earth. At the laying of each brick they bring near it the branch of the compasses, on which the curve of the core is shaped, so that there may remain between it and the curve the distance of a line, to be afterwards filled up with layers of cement. The work is continued to the top, only leaving an opening for the coals to bake the core. This work is covered with a layer of cement, made of earth and horse-dung, on which they move the compasses of construction, to make it of an even smoothness every where.

The first layer being finished, they put the fire to the core, by filling it half with coals, through an opening that is kept shut, during the baking, with a cake of earth, that has been separately baked. The first fire consumes the stake, and the fire is left in the core half, and sometimes a whole day; the first layer being thoroughly dry, they cover it with a second, third, and fourth; each being smoothed by the board of the compasses, and thoroughly dried before they proceed to another.

The core being completed, they take the compasses to pieces, with intent to cut off the thickness of the model, and the compasses are immediately put in their place, to begin a second piece of the mould. It consists of a mixture of earth and hair, applied with the hand on the core, in several cakes that close together. This work is finished by several layers of a thinner cement of the same matter, smoothed by the compasses, and thoroughly dried before another is laid on. The first layer of the model is a mixture of wax and grease spread over the whole. After which are applied the inscriptions, coats of arms, &c. besmeared with a pencil dipt in a vessel of wax in a chaffing-dish: this is done for every letter. Before the shell is begun, the compasses are taken to pieces, to cut off all the wood that fills the place of the thickness to be given to the shell.

The first layer is the same earth with the rest, sifted very fine; whilst it is tempering in water, it is mixed with cow's hair, to make it cohere. The whole being a thin cullis, is gently poured on the model, that fills exactly all the sinuosities of the figures, &c. and this is repeated till the whole is two lines thick over the model. When this layer is thoroughly dried, they cover it with a second of the same matter, but something thicker: when this second layer becomes of some consistence, they apply the compasses again, and light a fire in the core, so as to melt off the wax of the inscriptions, &c.

After this, they go on with other layers of the shell, by means of the compasses. Here they add to the cow's hair a quantity of hemp, spread upon the layers, and afterwards smoothed by the board of the compasses. The thickness of the shell comes to four or five inches lower than the mill-stone before observed, and surrounds it quite close, which prevents the extravasation of the metal. The wax should be taken out before the melting of the metal.

The ear of the bell requires a separate work, which is done during the drying of the several incrustations of the cement. It has seven rings, the seventh is called the bridge, and unites the others, being a perpendicular support to strengthen the curves. It has an aperture at the top, to admit a large iron-peg bent at the bottom; and

this is introduced into two holes in the beam, fastened with two strong iron-keys. There are models made of the rings, with masses of beaten earth, that are dried in the fire, in order to have the hollow of them. These rings are gently pressed upon a layer of earth and cow's hair, one half of its depth; and then taken out, without breaking the mould. This operation is repeated twelve times for twelve half-moulds, that two and two united make the hollows of the six rings: the same they do for the hollow of the bridge, and bake them all, to unite them together.

Upon the open place left for the coals to be put in, are placed the rings that constitute the ear. They first put into this open place the iron-ring to support the clapper of the bell; then they make a round cake of clay, to fill up the diameter of the thickness of the core. This case after baking, is clapped upon the opening, and soldered with a thin mortar spread over it, which binds the cover close to the core.

The hollow of the model is filled with an earth, sufficiently moist, to fix on the place which is strewed, at several times, upon the cover of the core; and they beat it gently with a pestle, to a proper height; and a workman smooths the earth at top with a wooden trowel dipped in water.

Upon this cover, to be taken off afterwards, they assemble the hollows of the rings. When every thing is in its proper place, they strengthen the outside of the hollows with mortar, in order to bind them with the bridge, and keep them steady at the bottom, by means of a cake of the same mortar which fills up the whole aperture of the shell. This they let dry, that it may be removed without breaking. To make room for the metal they pull off the hollows of the rings, through which the metal is to pass, before it enters into the vacuity of the mould. The shell being unloaded of its ear, they range under the mill-stone five or six pieces of wood, about two feet long, and thick enough to reach almost the lower part of the shell; between these and the mould they drive in wooden wedges with a mallet, to shake the shell of the model whereon it rests, so as to be pulled up and got out of the pit.

When this and the wax are removed, they break the model and layer of earth, through which the metal must run, from the hollow of the rings, between the shell and the core. They smoke the inside of the shell, by burning straw under it that helps to smooth the surface of the bell. Then they put the shell in the place, so as to leave the same interval between that and the core; and before the hollows of the rings or the cap are put on again, they add two vents, that are united to the rings, and to each other, by a mass of baked cement. After which they put on this mass of the cap, the rings, and the vent, over the shell, and solder it with thin cement, which is dried gradually by covering it with burning coals. Then they fill up the pit with earth, beating it strongly all the time round the mould.

The furnace has a place for the fire, and another for the metal. The fire-place has a large chimney with a spacious ash-hole. The furnace which contains the metal, is vaulted, the bottom is made of earth, rammed down; the rest is built with brick. It has four apertures; the first, through which the flame reverberates; the second is closed with a stoppel that is opened for the metal to run; the others are to separate the dross or scoriæ, of the metal by wooden rakes: through these last apertures passes the thick smoke. The ground of the furnace is built sloping, for the metal to run down.

Foundery *of great guns and mortar pieces.* The method of casting these pieces is little different from that of bells: they are run massy, without any core, being determined by the hollow of the shell; and they are afterwards bored with a steel trapan, which is worked either by horses, or a water-mill.

For the metal parts, proportions, &c. of these pieces. See Cannon.

Foundry, *letter*, or casting of printing letters. See Type.

FOUNT, or *font*, among printers, a set or quantity of letters, and all the appendages belonging thereto, as numeral characters, quadrates, points, &c. cast by a letter-founder, and sorted. Founts are large or small, according to the demand of the printer, who orders them by the hundred weight, or by sheets. When a printer orders a fount of five hundred, he means that the fount, consisting of letters, points, spaces, quadrates, &c. shall weigh 500lb. When he demands a fount of ten sheets, it is understood, that with that fount he shall be able to compose ten sheets, or twenty forms, without being obliged to distribute, that is, take them to pieces. The founder proceeds accordingly; he reckons 120lb. for a sheet, including the quadrates, &c. or 60lb. for a form, which is only half a sheet: not that the sheet always weighs 120lb. or the form 60lb. on the contrary it varies according to the size of the form: besides, it is always supposed that there are letters left in the cases. As therefore every sheet does not comprehend the same number of letters, nor the same sort of letters, we must observe, that, as in every language some sounds recur more frequently than others, some letters will be in much more use, and oftener repeated than others, and consequently their cells or cases should be better stored than those of the letters which do not recur so frequently: thus, a fount does not contain an equal number of *a* and *b*, or of *b* and *c*, &c. the letter-founders have therefore a list or tariff, or, as the French call it, a police, by which they regulate the proportions between the different sorts of characters that compose a fount; and it is evident that this tariff will vary in different languages, but will remain the same for all sorts of characters employed in the same language. See Printing.

FOUNTAIN, or *artificial fountain* in hydraulics, called also a jet d'eau, is a contrivance by which water is violently spouted upwards. See Hydraulics.

FOURCHE'E, or fourchy, in heraldry, an appellation given to a cross forked at the ends.

Fourche'e, or *fourching*, in law, signifies the delaying or putting off an action, which might have been brought to determination in a shorter time.

FOURTEENTH, in music, the octave, or replicate, of the seventh. A distance comprehending thirteen diatonic intervals.

FOURTH, in music, a distance comprising three diatonic intervals: *i. e.* two tones and a half. The fourth is the third of the consonances in the order of their generation.

Lesser Fourth, an interval consisting of five semitones.

Greater or sharp Fourth, an interval consisting of six semitones.

FOX. See Canis.

Fox-glove See Digitalis.

FRACTION. See Algebra and Arithmetic.

FRACTURE, in surgery, a rupture of a bone, or a solution of a continuity in a bone, when it is crushed or broken by some external cause. See Surgery.

FRAGARIA, the strawberry; a genus of the polygynia order, in the icosandria class of plants; and in the natural method ranking under the 35th order, senticosæ. The calyx is decemfid; the petals five; the receptacle of the seeds ovate, in the form of a berry and deciduous. There are three species, but only one is deserving of particular notice, viz. I. the vesca, or cultivated strawberry. The principal varieties are, 1. The sylvestris, or wood strawberry, with oval sawed leaves, and small round fruit. 2. The Virginian scarlet, or Virginia strawberry with oblong oval sawed leaves, and a roundish scarlet coloured fruit. 3. The moschatta, or hautboy, or musky strawberry, having oval, lanceolate rough leaves, and large pale red fruit. 4. The chiloensis, or Chili strawberry, of which the carolina is a variety with large, oval, thick, downy leaves, large flowers, and very large firm fruit. 5. The alpina, alpine, or monthly strawberry, having small oval leaves, small flowers, and moderate-sized, oblong, pointed fruit. All these varieties are hardy, low, perennials, durable in root; but the leaves and fruit-stalks are renewed annually in spring. They flower in May and June, and their fruit comes to perfection in June, July, and August; the alpine kind continuing till the beginning of winter. They all thrive in any common garden soil, producing abundant crops annually without much trouble. They increase exceedingly every summer, both by off-sets or suckers from the sides of the plants, and by the runners or strings, all of these rooting and forming plants at every joint, each of which separately planted bears a few fruit the following year, and bear in great perfection the succeeding summer. Those of the alpine kind will even bear fruit the same year that they are formed. All the sorts are commonly cultivated in kitchen-gardens, in beds or borders of common earth, in rows lengthwise 15 or 18 inches distance; the plants the same distance from one another in each row. Patches of the different sorts, disposed here and there in the fronts of the different compartments of the pleasure-ground, will appear ornamental both in their flowers and fruit, and make an agreeable variety. Strawberries, eaten either alone, or with sugar and cream, are universally esteemed a most delicious fruit. They are grateful, cooling, subacid, and juicy. Though taken in large quantities, they seldom disagree. They promote perspiration, impart a violet smell to the urine, and dissolve the tartareous incrustations on the teeth. People afflicted with the gout or stone have found relief by using them very largely; and Hoffman says, he has known consumptive people cured by them. The bark of the root is astringent. Sheap and goats eat the plant; cows are not found of it; horses and swine refuse it.

II. The monophylla, or simple leaved strawberry, produces also esculent fruit, and differs from the former species only in the leaf.

III. The sterilis, or barren strawberry, is destitute of fruit, though it perfects seed.

FRÆNUM, in anatomy, a term applied to some membranous ligaments of the body.

Frænum linguæ, the ligament under the tongue, which sometimes ties it down too close to the bottom of the mouth; and then requires to be incised or divided, in order to give this organ its proper and free motion.

FRAISE, in fortification, a kind of defence consisting of pointed stakes, six or seven feet long, driven parallel to the horizon into the retrenchments of a camp, a half-moon, &c. and to prevent any approach or scalade. See Fortification.

FRANCHISE, in a general sense, a privilege or exemption from ordinary jurisdiction; as that for a corporation to hold pleas among themselves to such a value, or the like.

Franchises and liberties being usually held by charter, are all said to be derived from the crown, but some lie in prescription without the help of any charter.

Farnchise royal, seems to be that where the king's writ does not run; but Bracton says, that a franchise royal is where the king grants to one and his heirs an exemption of toll, &c.

Franchise of quarters, a certain place or district at Rome, wherein are the houses of the ambassadors of the princes of Europe; and where such as retire cannot be arrested or seized by the shirri or serjeants, nor prosecuted at law. Several of the popes published their bulls and ordinances against the abuse made of this privilege, which rescued so considerable a part of the city, by the enlargement of these places, from their authority, and rendered them a retreat for the most abandoned persons. At last Innocent XI. expressly refused to receive any more ambassadors, but such as would make a formal renunciation of the franchise of quarters.

FRANCISCAN MONKS, Friars' Minor, or Grey Friars, religious of the order of St. Francis, founded by him in the year 1209.

The rule of the Franciscans, as established by St. Francis himself, is briefly this: they are to live in common, to observe chastity, and to pay obedience to the pope and their superiors. Before they can be admitted into the order they are obliged to sell all they have, and give it to the poor: they are to perform a year's noviciate, and when admitted, never to quit the order on any account. They are to fast from the feast of All Saints to the Nativity. This order has produced four popes, forty-two cardinals, and an infinite number of patriarchs. The Franciscans had sixty-three monasteries in England, one of which was in the parish of St. Nicholas in London. It is said this order possessed (before the French revolution) 40,000 monasteries, hermitages, or chapels, in the different quarters of the globe.

FRANK ALMOIGN, signifies a tenure by spiritual service, where lands or tenements were held by an ecclesiastical corporation, sole or aggregate, to them and their successors, of some lord and his heirs, in free and perpetual alms.

Frank fee, signifies the same thing as holding lands and tenements in fee simple; that is, to any person and his heirs, and not by such services as is required by ancient demesne, but is pleaded at common law.

Frank ferm, anciently signified lands charged in the nature of the fee by feoffment, &c. out of the knight's service for other certain yearly services.

Frank fold, is where the lord has the liberty of folding his tenants' sheep within his manor.

Frank incense, in chemistry. It is well known that a resinous juice exudes from the pinus sylvestris, or common Scotch fir, which hardens into tears. The same, or a similar exudation, appears in the spruce fir. These tears constitute the substance called *thus*, or common frankincense. See Resin and Pinus.

Franklanguage, or *lingua franca*, a kind of jargon spoken on the Mediterranean, and particularly throughout the coasts and parts of the Levant, composed of Italian, Spanish, French, vulgar Greek, and other languages.

Frank law, a word applied to the free and common law of the land, or the benefit a person has by it.

Frank marriage, is where a person, seized in fee of lands or tenements, has given them to another with his daughter, sister, or some women otherwise of kin to him, in free marriage, by virtue of which the husband and wife have an estate in special tail, and shall hold the land of the donor, discharged of all services, except fealty, to the fifth degree.

Frank pledge, in English law, signifies a pledge or surety for the behaviour of freemen. According to the ancient custom of England, for the preservation of the public peace, every free-born man, at the age of 14, except religious persons, clerks, knights, and their eldest sons, was obliged to give security for his truth and behaviour towards the king and his subjects, or else be imprisoned. Accordingly, a certain number of neighbours became interchangeably bound for each other, to see each person of their pledge forthcoming at all times, or to answer for the offence of any one gone away; so that whenever any person offended, it was presently inquired in what pledge he was; and there the persons bound either produced the offender in 31 days, or made satisfaction for his offence.

Frank, or Franc, an ancient coin, either of gold or silver, struck and current in France. The value of the gold frank was somewhat more than that of the gold crown; the silver frank was a third of the gold one: this coin is long out of use, though the term is still retained as the name of a money of account; in which sense it is equivalent to the livre, or 20 sols.

FRANKENIA, *sea-heath*, or *sea-chick-weed*, a genus of the hexandria monogynia class of plants, the flower of which consists of five petals, with a plain limb: the fruit is an oval, unilocular capsule, covered by the cup, and containing a great many ovated very small seeds. There are three species of this weed.

FRATERNITY, in the Roman catholic countries, signifies a society for the improvement of devotion.

Fraternity, in a civil sense, a company or guild of certain artificers or traders.

FRATRICELLI, *little brothers*, in church history, a sect of heretics who appeared in Italy about the year 1298, and afterwards spread all over Europe. They wore the habit of the Franciscan order, and pretended that ecclesiastics ought to have no possessions of their own.

FRATRIAGE, the partition among brothers or coheirs, coming to the same inheritance or succession. It more particularly signifies a younger brother's inheritance; or whatever the younger sons possess of the father's estate, which, in our ancient law, they are said to enjoy ratione fratriagii; and were to do homage for the same to the elder brother, he being bound to do homage to the superior lord for the whole.

FRAUD, in law. All deceitful practices in defrauding or endeavouring to defraud another of his own right, by means of some artful device, contrary to the plain rules of common honesty, are condemned by the common law, and punishable according to the heinousness of the offence. Co. Lit, b. 3.

The distinction laid down as proper to be attended to in all cases of this kind, is this, that in such impositions or deceits, where common prudence might guard persons from the offence, it is not indictable, but the party is left to his civil remedy; but where false weights or measures are used, or false tokens produced, or such measures taken to defraud or deceive, as people cannot by any ordinary care or prudence be guarded against, there it is an offence indictable. Burr. 1120.

Persons convicted of obtaining money or goods by false pretences, or sending threatening letters to extort money or goods, may be punished by fine and imprisonment, or by pillory, whipping, or transportation. 30 G. II. c. 24.

A fraudulent conveyance of lands or goods to deceive creditors, as to creditors is void in law. And a fraudulent conveyance in order to defraud purchasers, is also to such purchasess void; and the persons justifying or putting off such grants as good, shall forfeit a year's value of the lands, and the full value of the goods and chattels, and likewise shall be imprisoned. When, however, conveyances are fraudently made, they are not void to all persons, but only to those that afterwards come to the land as purchasers on good consideration. A general gift made of all the goods of a person may be reasonably suspected to be by fraud, even though a true debt is owing to the party to whom made; and it is void against other creditors of the donor. Here the several marks of fraud in a gift or grant of goods, are as follow, viz. 1. If it is general, without any exception of some things of necessity. 2. If the donor continues to possess and use the goods. 3. If the deed is made in secret. 3. If there is a trust between the parties; or, 5. If made whilst the action is depending. Where a person is party to a fraud, all that follows thereupon will be intended to be done by him, though fraud shall not be presumed or adjudged to be so, until found by jury.

By the statute of frauds, 29 Car. II. agreements for the sale of lands, leases, &c. are required to be in writing. See 3 and 4 Will. and Mary, c. 14.

FRAXINUS, the *ash*, a genus of the diœcia order, in the polygamia class of plants, and in the natural method ranking under the 44th order, sepiariæ. There is no hermaphrodite calyx, or it is quadripartite; and there is either no corolla, or it is tetrapetalous; there are two stamina, one pistil, one lanceolated seed, and the pistil of the female is lanceolated. There are four species, of which the most useful is the common ash, which is so well known that it needs no description. If a wood of these trees is rightly managed, it will turn

greatly to the advantage of the owner: for by the underwood, which will be fit to cut every eight or ten years, there will be a continual income, more than sufficient to pay the rent of the ground and all other charges; and still there will be a stock preserved for timber, which in 23 years will be worth 114*l.* per acre. This tree flourishes best in groves, but grows very well in rich soil in open fields. It bears transplanting and lopping. In the north of Lancashire they lop the tops of these trees to feed the cattle in autumn when the grass is on the decline, the cattle peeling off the bark as food. The wood has the singular property of being nearly as good when young as when old. It is hard and tough, and is much used to make the tools employed in husbandry. The ashes of the wood afford very good potash. The bark is used in tanning calf-skin. A slight infusion of it appears of a pale yellowish colour, when viewed betwixt the eye and the light; but when looked down upon, or placed betwixt the eye and an opaque object, appears blue. This blueness is destroyed by the addition of an acid, but recovered by alkalies. The seeds are acrid and bitter. In the church-yard of Lochabar in Scotland, Dr. Walker measured the trunk of a dead ash-tree, which, at five feet from the surface of the ground, was 58 feet in circumference.

FREE, among seamen. The pump is said to free the ship, when it throws out the water faster than it leaks into her. To free the boat, is bailing or lading out the water therein.

Free-bench, signifies that estate in copyhold which the wife, being espoused a virgin, has after the decease of her husband for her dower, according to the custom of the manor. In regard to this free-bench, different manors have different customs, and in the manor of east and west Enbourne in the county of Berks, and in other parts of England, there is a custom, that when a copyhold tenant dies, the widow shall have her free-bench in all the deceased husband's lands, dum sola et casta fuerit, while she lives single and chaste; but if she is found to be guilty of incontinency, she shall forfeit her estate. Nevertheless, upon her coming into the court of the manor riding backwards on a black ram, with his tail in her hand, rehearsing a certain form of words, the steward is bound by custom to restore her to her free-bench.

FREEDOM of a corporation, the right of enjoying all the privileges and immunities belonging to it.

The freedom of cities, and other corporations, is regularly obtained by serving an apprenticeship of seven years; but it is also sometimes purchased with money, and sometimes conferred by way of compliment.

FREEHOLD, may be in deed or in law. A freehold in deed is actual seisin of lands or tenements in fee-simple, fee-tail, or for life. A freehold in law is a right to such lands or tenements before entry or seizure.

So there is a seisin in deed, and a seisin in law. A seisin in deed is when a corporal possession is taken; and a seisin in law is where lands descend before entry, or where something is done which amounts in law to an actual seisin. 1 Inst. 31.

Tenant in fee-simple, or fee-tail for life, is said to have a freehold, so called because it distinguishes it from terms of years, chattels upon uncertain interests, lands in villenage, or customary or copyhold lands. 1 Inst. 43.

A freehold cannot be conveyed to pass in future; for then there would be want of a tenant against whom to bring a præcipe; and therefore, notwithstanding such conveyance, the freehold continues in the vendor: but if livery of seisin is afterwards given, the freehold thence passes to the vendee. 2 Wils. 165.

A man is said to be seised of freehold, but to be possessed of other estates, as of copyhold lands, leases for years, or goods and chattels. See Estate and Fee simple.

FREEHOLDERS, such as hold any freehold estate.

FREESTONE, a whitish stone dug up in many parts of England, that works like alabaster, but is more hard and durable, being of excellent use in building, &c. It is a variety of the gritstone, but finer sanded, and a smoother stone, and is called free, from its being of such a constitution as to cut freely in any direction: such is the Portland-stone, and the freestone of Kent.

FREEZE, or Frieze, in commerce, a coarse kind of woollen stuff, or cloth, for winter wear; so called as being freezed or naped on one side.

Freezing, in philosophy, the same with congelation, or the fixing a fluid body into a firm or solid mass by the action of cold. See Cold.

In general cold contracts most bodies, and heat expands them: though there are some instances to the contrary, especially in the extreme cases or states of these qualities of bodies. Thus, though iron, in common with other bodies, expands with heat, yet, when melted, it is always found to expand in cooling again. So also, though water always is found to expand gradually as it is heated, and to contract as it cools, yet in the act of freezing it suddenly expands again, and that with a most enormous force, capable of rending rocks, or bursting very thick shells of metal, &c. A computation of the force of freezing water has been made by the Florentine academicians, from the bursting of a very strong brass globe or shell, by freezing water in it; when, from the known thickness and tenacity of the metal, it was found that the expansive power of a spherule of water only one inch in diameter was sufficient to overcome a resistance of more than 27,000lbs. or 13 tons and a half. See the experiments on bursting thick bomb-shells, by freezing water in them, by major Edward Williams, of the royal artillery, in the Edin. Philos. Trans. vol. ii.

Such a prodigious power of expansion, almost double that of the most powerful steam engines, and exerted in so small a mass, seemingly by the force of cold, was thought a very material argument in favour of those who supposed that cold, like heat, is a positive substance. Dr. Black's discovery of latent heat, however, has now afforded a very easy and natural explication of this phenomenon. He has shown that, in the act of congelation, water is not cooled more than it was before, but rather grows warmer: that as much heat is discharged, and passes from a latent to a sensible state, as, had it been applied to water in its fluid state, would have heated it to 135°. In this process the expansion is occasioned by a great number of minute bubbles suddenly produced. Formerly these were supposed to be cold in the abstract; and to be so subtile that, insinuating themselves into the substance of the fluid, they augmented its bulk, at the same time that, by impeding the motion of its particles upon each other, they changed it from a fluid to a solid. But Dr. Black shows, that these are only air extricated during the

congelation; and to the extrication of this air he ascribes the prodigious expansive force exerted by freezing water. The only question, therefore, now remaining is, by what means this air is extricated, and to take up more room than it naturally does in the fluid? To this it may be answered, that perhaps part of the heat, which is discharged from the freezing water, combines with the air in its unelastic state, and, by restoring its elasticity, gives it that extraordinary force, as is seen also in the case of air suddenly extricated in the explosion of gunpowder.

Cold also usually tends to make bodies electric, which are not so naturally, and to increase the electric properties of such as are so. And it is farther found, that all substances do not transmit cold equally well; but that the best conductors of electricity, viz. metals, are likewise the best conductors of cold. It may farther be added, that when the cold has been carried to such an extremity as to render any body an electric, it then ceases to conduct the cold so well as before. This is exemplified in the practice of the Laplanders and Siberians; where, to exclude the extreme cold of the winters from their habitations the more effectually, and yet to admit a little light, they cut pieces of ice, which in the winter time must always be electric in those countries, and put them into their windows; which they find to be much more effectual in keeping out the cold than any other substance.

Cold, or rather the absence of heat, is the destroyer of all vegetable life, when increased to an excessive degree. It is found that many garden plants and flowers, which seem to be very stout and hardy, go off at a little increase of cold beyond the ordinary standard. And, in severe winters, nature has provided the best natural defence for the cornfields and gardens, namely, a covering of snow, which preserves such parts green and healthy as are under it, while such as are uncovered by it are either killed or greatly injured.

Although the thermometer in England hardly ever descends so low as 0, yet, in the winter of 1780, Mr. Wilson, of Glasgow, observed, that a thermometer laid on the snow sunk to 25° below 0; and Mr. Derham, in the year 1708, observed in England that the mercury stood within one-tenth of an inch of its station when plunged into a mixture of snow and salt. At Petersburgh, in 1732, the thermometer stood at 28° below 0; and when the French academicians wintered near the polar circle, the thermometer sunk to 33° below 0; and in the Asiatic and American continents still greater degrees of cold are often observed.

The effects of these extreme degrees of cold are very surprising. Trees are burst, rocks rent, and rivers and lakes frozen several feet deep: metallic substances blister the skin like red-hot iron: the air, when drawn in by breathing, hurts the lungs, and excites a cough: even the effects of fire, in a great measure, seem to cease; and it is observed, that though metals are kept for a considerable time before a strong fire, they will still freeze water when thrown upon them. When the French mathematicians wintered at Tornea, in Lapland, the external air, when suddenly admitted into their rooms, converted the moisture of the atmosphere into whirls of snow; their breasts seemed to be rent when they breathed it, the contact of it was intolerable to their bodies; and the spirit of wine, which had not been highly rectified, burst some of their thermometers by the congelation of the aqueous part.

Extreme cold too often proves fatal to animals in those countries where the winters are very severe: thus 7000 Swedes perished at once in attempting to pass the mountains which divide Norway from Sweden. But it is not necessary that the cold, in order to prove fatal to human life, should be so very intense as has just been mentioned; it is only requisite to be a little below 32° of Fahrenheit, or the freezing point, accompanied with snow or hail, from which shelter cannot be obtained. The snow which falls upon the cloths, or the uncovered parts of the body, then melts, and by a continual evaporation carries off the animal heat to such a degree, that a sufficient quantity is not left for the support of life. In such cases, the person first feels himself extremely chill and uneasy; he turns listless, unwilling to walk or use exercise to keep himself warm, and at last turns drowsy, sits down to refresh himself with sleep, but wakes no more.

With regard to the term congelation, it is applied to water when it freezes into ice; to metals, when they resume their solid form after being melted by heat; or to glass, wax, pitch, tallow, &c. when they harden again after having been rendered fluid by heat. But it differs from crystallization, which is rather a separation of the particles of a solid from a fluid in which it had been dissolved more by the moisture than the action of heat.

The process of congelation is always attended with the emission of heat, as is found by experiments on the freezing of water, wax, spermacceti, &c.; for in such cases it is always found that a thermometer dipt into the fluid mass keeps continually descending as this cools, till it arrives at a certain point; being the point of freezing, which is peculiar to each fluid, where it is rather stationary, and then rises for a little, while the congelation goes on.

Freezing-point, denotes the point or degree of cold, shown by a mercurial thermometer, at which certain fluids begin to freeze, or, when frozen, at which they begin to thaw again. On Fahrenheit's thermometer this point is at + 32 for water, and at — 40 for quicksilver, these fluids freezing at those two points respectively. It would also be well if the freezing points for other fluids were ascertained, and the whole arranged in a table. See Thermometer.

Freezing-rain, or *raining ice*, a very uncommon kind of shower, which fell in the west of England, in December 1762, of which we have various accounts in the Philosophical Transactions. This rain, as soon as it touched any thing above ground, as a bough, &c. immediately settled into ice; and, by multiplying and enlarging of the icicles, broke all down with its weight. The rain that fell on the snow immediately froze into ice, without sinking in the snow at all. It made an incredible destruction of trees, beyond any thing in all history. "Had it concluded with some gust of wind (says a gentleman on the spot), it might have been of terrible consequence. I weighed the sprig of an ash-tree, of just three-quarters of a pound, the ice on which weighed 16 pounds. Some were frightened with the noise in

the air, till they discerned it was the clatter of icy boughs, dashed against each other." This phenomenon, however, is not uncommon in a less degree, and depends wholly on the nice balance of temperatures in the rain and atmosphere. Dr. Beale observes, that there was no considerable frost observed on the ground during the whole; whence he concludes, that a frost may be very intense and dangerous on the tops of some hills and plains; while in other places it keeps at two, three, or four feet distance above the ground, rivers, lakes, &c. and may wander about very furious in some places, and remiss in others not far off. The frost was followed by glowing heats, and a wonderful forwardness of flowers and fruits.

Freezing mixture. See Cold.

FREIGHT, or Fraight, in navigation and commerce, is the consideration of money agreed to be paid for the use of hire of a ship, or, in a larger sense, the burthen of such ship.

The freight is most frequently determined for the voyage, without respect to time: sometimes it depends on time; in the former case it is either fixed at a certain sum for the whole cargo, or so much per ton, barrel bulk, or other weight or measure, or so much per cent. on the value of the cargo.

If a certain sum is agreed on for the freight of the ship, it must all be paid, although the ship when measured should prove less, unless the burthen is warranted. If the ship is freighted for transporting cattle or slaves at so much per head, and some of them die on the passage, freight is only due for such as are delivered alive; if for lading them, it is due for all put on board.

When a whole ship is freighted, if the master suffers any goods besides those of the freight to be put on board, he is liable for damages.

If the voyage is completed according to the agreement, without any accident, the master has a right to demand the freight before the delivery of the goods; but if such delivery is prevented by negligence or accidents, the parties will be reciprocally responsible in the following manner.

If the merchant should not load the ship within the time agreed on, the master may engage with another, and recover damages.

If the merchant recals the ship after she is laden and sailed, he must pay the whole freight; but if he unloads before the ship has actually sailed, he will in such case only be responsible for damages.

If the merchant loads goods which are not lawful to export, and the ship is prevented from proceeding on that account, he must nevertheless pay the freight.

If the master is not ready to proceed on the voyage at the time stipulated, the merchant may load the whole or part of the cargo on board another ship, and recover damages; but any real casualties will release the master from all damages.

If an embargo is laid on the ship before she sails, the charterparty is dissolved, and the merchant pays the expense of loading and unloading; but if the embargo is only for a short limited time, the voyage shall be performed when it expires; and neither party is liable for damages.

If the master sails to any other port than that agreed on, without necessity, he must sail to the port agreed on at his own expense, and is also liable for any damages in consequence of it.

If a ship is taken by the enemy, and retaken or ransomed, the charterparty continues in force.

If the master transfers the goods from his own ship to another, without necessity, and they perish, he is responsible for the full value, and all charges; but if his own ship is in imminent danger, the goods may be put on board another ship at the risk of the owner.

If a ship is freighted out and home, and a sum agreed on for the whole voyage, nothing becomes due until the return of such ship.

If a certain sum is specified for the homeward voyage, it is due, although the correspondent abroad should have no goods to send home.

A ship was freighted to a particular port and home, a particular freight agreed upon for the homeward voyage, with an option reserved for the correspondent to decline it, unless the ship arrived before a certain day. The master did not go to the port agreed on, and therefore became liable to damages; the obligation being absolute on his part, and conditional only on the part of the freight.

If the goods are damaged without fault of the ship or master, the owner is not obliged to receive them and pay the freight, but he must either receive or abandon the whole; he cannot receive those that are not damaged, and reject the others.

If the goods are damaged through the insufficiency of the ship, the master is liable for the same; but if it is owing to stress of weather he is not accountable.

If part of the goods are thrown overboard, or taken by the enemy, the part delivered pays freight.

The master is accountable for all the goods received on board by himself and mariners, unless they perish by the act of God, or the king's enemies.

The master is not liable for leakage of liquors, nor accountable for contents of packages, unless packed in his presence.

FRESCO, a method of painting in relievo on walls, so as to endure the weather.

It is performed with water-colours on fresh plaster; or a wall laid with mortar not yet dry. This sort of painting has a great advantage by its incorporating with the mortar, and drying along with it, becomes very durable.

The ancients painted on stucco; and we may remark in Vitruvius, what infinite care they took in making the incrustations or plastering of their buildings, to render them beautiful and lasting; though the modern painters find a plaster of lime and sand preferable to it. See Painting.

FRESHES, in sea language, denote the impetuosity of an ebb-tide, increased by heavy rains, and flowing out into the sea, often discolouring it to a considerable distance, and forming a line that separates the two colours, and which may be distinctly perceived for a great length along the coast.

FRET, Frette, in architecture, a kind of knot, or ornament, consisting of two lists or small fillets variously interlaced or interwoven, and running at parallel distances equal to their breadth. See Architecture.

Fret, in heraldry, a bearing composed of six bars, crossed, and variously interlaced. Some call it the true-lover's knot.

Fret, in music, signifies a kind of stop on some instruments, particularly bass-viols and lutes. Frets consists of strings tied round the neck of the instrument, at certain distances, within which such and such notes are to be found.

Fret-work. See **Architecture.**

FRETTY, in heraldry, an appellation given to bearings made up of six, eight, or more bars laid across each other in the manner of frets.

FRIAR, or **Frier**, from the French *frere*, a brother, a term common to monks of all orders, founded on this, that there is a kind of fraternity, or brotherhood, between the several religious persons of the same convent or monastery. Friars are generally distinguished into these four principal branches, viz. 1. Minors, grey friars, or franciscans. 2. Augustines. 3. Dominicans, or black friars. 4. White friars, or carmelites. From these four the rest of the orders descend. See the articles **Franciscans, Augustines**, &c.

Friar observant, is a branch of the franciscan friars; thus called, because they are not combined together in any cloister, convent, or corporation, as the conventuals are; but have bound themselves only to observe the rules of their order more strictly than the conventuals do, from whom they separated, out of a singularity of zeal, living in certain places of their own choosing.

FRICTION, in mechanics, is the resistance which a body meets with from the surface on which it moves.

It is hardly possible to lay down general rules concerning the quantity of friction; since it depends upon a multiplicity of circumstances, as the structure, firmness, elasticity, &c. of the bodies rubbing against each other. Some authors make friction upon an horizontal plane, equal to one third of the weight to be moved; whilst others have found it to be considerably less.

Two objects must however be observed, viz. the loss of power which is occasioned by it, and the contrivances which have been made, and are in use, for the purpose of diminishing its effects.

A body on an horizontal plane should be capable of being moved by the application of the least force; but this is not the case, and the principal causes which render a greater or less quantity of force necessary for it are, 1st, the roughness of the contiguous surfaces; 2dly, the irregularity of the figure, which arises either from the imperfect workmanship, or from the pressure of one body upon the other; 3dly, an adhesion or attraction which is more or less powerful according to the nature of the bodies in question; and 4thly, the interposition of extraneous bodies; such as moisture, dust, &c.

Innumerable experiments have been made for the purpose of determining the quantity of obstruction, or of friction, which is produced in particular circumstances. But the results of apparently similar experiments, which have been made by different experimenters, do not agree; nor is it likely they should, since the least difference of smoothness or polish, or of hardness, or, in short. of any of the various concurring circumstances, produces a different result. Hence no certain and determinate rules can be laid down with respect to the subject of friction.

Mr. Vince, who has made many experiments on friction, infers,

1st, That friction is an uniformly retarding force in hard bodies, not subject to alteration by the velocity; except when the body is covered with cloth, woollen, &c. and in this case the friction increases a little with the velocity.

2dly, Friction increases in a less ratio than the quantity of matter or weight of the body. This increase, however, is different for the different bodies, more or less; nor is it yet sufficiently known, for any one body, what proportion the increase of friction bears to the increase of weight.

3dly. The smallest surface has the least friction, the weight being the same. But the ratio of the friction to the surface is not yet accurately known.

Mr. Vince's experiments consisted in determining how far the sliding bodies would be drawn in given times, by a weight hanging freely over a pulley. This method would both show him if the friction was a constant retarding force, and the other conclusions above stated. For as the spaces described by any constant force, in given times, are as the squares of the times, and as the weight drawing the body is a constant force, if the friction, which acts in opposition to the weight, should also be a constant force, then their difference, or the force by which the body is urged, will also be constant, in which case the spaces described ought to be as the squares of the times, which happened accordingly in the experiments.

Mr. Vince adds some remarks on the nature of the experiments which have been made by others. These, he observes, the authors "have instituted to find what moving force would just put a body at rest in motion, and they concluded thence that the accelerative force was then equal to the friction; but it is manifest, that any force which will put a body in motion must be greater than the force which opposes its motion, otherwise it could not overcome it: and hence, if there were no other objections than this, it is evident that the friction could not be very accurately obtained; but there is another objection, which totally destroys the experiment, so far as it tends to show the quantity of friction, which is the strong cohesion of the body to the plane when it lies at rest." This he confirms by several experiments, and then adds: "From these experiments, therefore, it appears how very considerable the cohesion was in proportion to the friction when the body was in motion; it being in one case almost $\frac{1}{3}$, and in another it was found to be very nearly equal to the whole friction. All the conclusions, therefore, deduced from the experiments which have been instituted to determine the friction, from the force necessary to put a body in motion, (and I have never seen any described but upon such a principle) have manifestly been totally false; as such experiments only show the resistance which arises from the cohesion and friction conjointly." Philos. Trans. vol. 75, pa. 165.

If a body is laid upon another body, and soon after is moved along the surface of it, a less force will be found sufficient for the purpose, than if the body be left some

time at rest before it be moved. This arises principally from an actual change of figure, which is produced in a longer or shorter time, according to the nature of the bodies. Thus the maximum of adhesion between wood and wood takes place in a few minutes' time; between metal and metal it takes place almost immediately. A hard and heavy body laid upon a softer one will sometimes continue to increase its adhesion for days and weeks.

When a cubic foot of soft wood of eight pounds weight is to be moved upon a smooth horizontal plane of soft wood, at the rate of three feet per second, the power which is necessary to move it, and which is equivalent to the friction, amounts to between 1-4th and 1-3d of the weight of the cube. When the wood is hard, the friction amounts to between 1-7th and 1-8th of the weight of the cube.

In general the softer or the rougher the bodies are, the greater is their friction. Yet when two pieces of metal, extremely well polished, are laid one upon the other with an ample surface of contact, they adhere to each other much more forcibly than when they are not so well polished.

Iron or steel moves easiest in brass. Other metals acting against each other produce more friction.

The friction, cæteris paribus, increases with the weight of the superincumbent body, and almost in the same proportion.

The friction or obstruction which arises from the bending of ropes about machines, is influenced by a variety of circumstances, such as their peculiar quality, the temperature of the atmosphere, and the diameter or curvature of the surface to which they are to be adapted. But when other circumstances remain the same, the difficulty of bending a rope increases with the square of its diameter, as also with its tension, and it decreases according as the radius of the curvature of the body to which it is adapted, increases.

Of the simple mechanical powers the lever is the least subject to friction.

In a wheel, the friction upon the axis is, as the weight that lies upon it, as the diameter of the axis, and as the velocity of the motion. But upon the whole, this sort of friction is not very great, provided the machine is well executed. In common pulleys, especially those of a small size, the friction is very great. It increases in proportion as the diameter of the axis increases, as the velocity increases, and as the diameter of the pulley decreases. With a moveable tackle, or block of five pulleys, a power of 150 pounds will barely be able to draw up a weight of 500 pounds.

The screw is subject to a great deal of friction; so much so that the power which must be applied to it, in order to produce a given effect, is at least double that which is given by the calculation independent of friction. But the degree of friction in the screw is influenced considerably by the nature of the construction; for much of it is owing to the tightness of the screw, to the distance between its threads, and to the shape of the threads; the square threads producing upon the whole, less friction than those which are sharp.

The friction which attends the use of the wedge, exceeds in general that of any other mechanical power. Its quantity depends so much upon the nature of the body upon which the wedge acts, besides other circumstances, that it is impossible to give even an approximate estimate of it.

The friction of mechanical engines not only diminishes the effect, or, which is the same thing, occasions a loss of power; but is attended with the corrosion and wear of the principal parts of the machine, besides producing a considerable degree of heat, and even actual fire; it is therefore of great importance in mechanics to contrive means capable of diminishing, if not of quite removing, the effects of friction.

In compound engines, the obstruction which arises from friction can be ascertained only by means of actual experiments. An allowance, indeed, may be made for each simple component mechanical power; but the error in estimating the friction of any one single power is multiplied and increased so fast by the other parts, that the estimate generally turns out very erroneous. Besides, much depends on the execution of the work; the quality of which cannot be learned but by experience. Novices are generally apt to expect too much or too little from any mechanism. In general it can only be said, that in compound engines, at least one-third of the power is lost on account of the friction.

The methods of obtaining the important object of diminishing the friction, are of two sorts, viz. either by the interposition of particular unctuous or oily substances between the contiguous moving parts, or by particular mechanical contrivances.

Olive-oil is the best, and perhaps the only substance that can be used in small works, as in watches and clocks, when metal works against metal. But in large works the oil is liable to drain off, unless some method is adopted to confine it. Therefore for large works tallow is mostly used, or grease of any sort; which is useful for metal, as well as for wood. In the last case tar is also frequently used.

In delicate works of wood, viz. when a piece of wood is to slide into or over wood, and when a wooden axis is to turn into wood, the fine powder of what is commonly called black-lead, when interposed between the parts, eases the motion considerably, and is at the same time a clean and durable substance.

Though olive-oil is the best and the only substance that is used for delicate mechanisms; yet it is far from being free from objections. Oil, when in contact with brass, is liable to grow rancid, in which state it slowly corrodes the brass. In different temperatures it becomes more or less fluid; but upon the whole it grows continually thicker, and of course less fit to ease the motion of the parts, &c. Trifling as those defects may at first sight appear, they are however of such moment in delicate works, that in the greatly improved state to which watchwork has been brought, the changeable quality of the oil seems at present to be the principal, if not the only impediment to the perfection of chronometers.

The mechanical contrivances which have been made, and are in use, for the purpose of diminishing the effects of friction, consist either in avoiding the contact of such bodies as produce much friction, or in the interposition of rollers, viz. cylindrical bodies, between the moving parts of machines, or between moving bodies in general. Such cylinders derive, from their various size and ap-

plication, the different names of rollers, friction-wheels, and friction-rollers.

Thus in mill-work and other large machines, the wooden axes of large wheels terminate in iron gudgeons, which turn in wood, or more frequently in iron or brass, which construction produces less friction than the turning of wood in wood. In the finest sort of watch-work the holes are jewelled, viz. many of the pivots of the wheels, &c. move in holes made in rubies, or topazes, or other hard stone, which, when well finished, are not liable to wear, nor do they require much oil.

In order to understand the nature of rollers, and the advantage with which their use is attended, it must be considered, that when a body is dragged over the surface of another body, the inequalities of the surfaces of both bodies meet and oppose each other, which is the principal cause of the friction or obstruction; but when one body, such as a cask, a cylinder, or a ball, is rolled upon another body, the surface of the roller is not rubbed against the other body, but is only successively applied to, or laid on, the other, and is then successively lifted up from it. Therefore, in rolling, the principal cause of friction is avoided, besides other advantages: hence a body may be rolled upon another body, when the shape admits of it, with incomparably less exertion than that which is required to drag it over the surface of that other body. In fact, we commonly see large pieces of timber, and enormous blocks of stone, moved upon rollers, that are laid between them and the ground, with ease and safety, when it would be almost impossible to move them otherwise.

The form and disposition of friction-wheels is represented by fig. 94, Plate LXIV. Miscel. which exhibits a front view of the axis of a large wheel, which moves between the friction-wheels A, B, C. Here the end of the axis (and the same thing must be understood of the opposite extremity of the axis) instead of moving in a hole, moves between the circumferences of three wheels, each of which is moveable upon its own axis, and is unconnected with the others. Now if the end of the axis turned in a hole, the surface of the hole would stand still, and the surface of the axis would rub against it; whereas, when the axis moves between the circumferences of the wheels A, B, C, its surface does not rub against, but is successively applied to the circumferences of those wheels; so that this sort of motion has the same advantage over the turning of the axis in a hole, that the moving of a heavy body upon rollers has over the simple method of dragging it upon the ground. In this construction the contact of the axis moves the wheels A, B, C, round their axis, where indeed some friction must unavoidably take place, but that friction is very trifling; for if the circumference of the axis be to that of each wheel as 1 to 20, the axis must make 20 revolutions whilst the friction-wheels will turn round once only.

A few years ago the same principle was applied in a very ingenious manner, by Mr. J. Garnett, then of Bristol, to pulleys, and other sorts of circular motion round an axis, for which he obtained a patent. The use of this application has proved very advantageous, especially on board of ships, where it has been found, that with a set of Mr. Garnett's pulleys, three men were able to draw as much weight as five men were barely able to accomplish with a similar set of common pulleys.

One of these pulleys is represented by fig. 95, Plate LXIV. Miscel. where the shaded part B B B is the pulley, A is the axis, round which are the cylindrical rollers, which are situated between the axis and the inside cavity of the pulley. The ends of the axis A are fixed in a block, after the usual manner. Every one of the rollers has an axis, the extremities of which turn in holes made in two brass or iron flat rings.

After having given a general explanation of the action of rollers, the advantage which Mr. Garnett's pulleys must have over those of the common sort, needs no farther illustration. We shall, however, only observe, that the friction of the pivots of each roller in the holes of the brass rings is very inconsiderable; for those holes are made rather large, the use of the axes to the rollers being only to prevent their running one against the other. Nor does the addition of weight upon the pulley increase that friction, for the addition of weight upon the pulley will press the rollers harder upon the axis A, but not upon their own axes, as may be easily understood by inspecting the figure. See Brewster's edition of Ferguson's Lectures.

Friction may be considered chemically as a source of caloric. Fires are often kindled by rubbing pieces of dry wood smartly against one another. It is well known that heavy loaded carts sometimes take fire by the friction between the axle-tree and the wheel. Now in what manner is the caloric evolved or accumulated by friction? Not by increasing the density of the bodies rubbed against each other, as happens in cases of percussion, for heat is produced by rubbing soft bodies against each other, the density of which therefore cannot be increased by that means, as any one may convince himself by rubbing his hand smartly against his coat. It is true, indeed, that heat is not produced by the friction of liquids; but then they are too yielding to be subjected to strong friction. It is not owing to the specific caloric of the rubbed bodies decreasing; for Count Rumford found that there was no sensible decrease, nor, if there was a decrease, would it be sufficient to account for the vast quantity of heat which is sometimes produced by friction.

Count Rumford took a cannon cast solid and rough, as it came from the foundery; he caused its extremity to be cut off, and formed, in that part, a solid cylinder attached to the cannon $7\frac{3}{4}$ inches in diameter, and $9\frac{8}{10}$ inches long. It remained joined to the rest of the metal by a small cylindrical neck. In this cylinder a hole was bored 3.7 inches in diameter and 7.2 inches in length. Into this hole was put a blunt steel borer, which by means of horses was made to rub against its bottom: at the same time a small hole was made in the cylinder perpendicular to the bore, and ending in the solid part a little beyond the end of the bore. This was for introducing a thermometer to measure the heat of the cylinder. The cylinder was wrapt round with flannel to keep in the heat. The borer pressed against the bottom of the hole with a force equal to about 10,000lbs. avoirdupois, and the cylinder was turned round at the rate of 32 times in a minute. At the beginning of the experiment the tempera-

ture of the cylinder was 60°; at the end of 30 minutes, when it had made 960 revolutions, its temperature was 130°. The quantity of metallic dust or scales produced by this friction amounted to 837 grains. Now if we were to suppose that all the caloric was evolved from these scales, as they amounted to just $\frac{1}{941}$ part of the cylinder, they must have given out 948° to raise the cylinder 1°, and consequently 66360° to raise it 70° or to 130°, which is certainly incredible.

Neither is the caloric evolved during friction, owing to the combination of oxygen with the bodies themselves, or any part of them. By means of a piece of clock-work, Mr. Pictet made small cups (fixed on the axis of one of the wheels), to move round with considerable rapidity, and he made various substances rub against the outsides of these cups, while the bulb of a very delicate thermometer placed within them marked the heat produced. The whole machine was of a size sufficiently small to be introduced into the receiver of an air-pump. By means of this machine a piece of adamantine spar was made to rub against a steel cup in air: Sparks were produced in great abundance during the whole time, but the thermometer did not rise. The same experiment was repeated in the exhausted receiver of an air-pump (the manometer standing at four lines); no sparks were produced, but a kind of phosphoric light was visible in the dark. The thermometer did not rise. A piece of brass being made to rub in the same manner against a much smaller brass cup in air, the thermometer (which almost filled the cup) rose 0.3°, but did not begin to rise till the friction was over. This shows us that the motion produced in the air carried off the caloric as it was evolved. In the exhausted receiver it began to rise the moment the friction began, and rose in all 1.2°. When a bit of wood was made to rub against the brass cup in the air, the thermometer rose 0.7°, and on substituting also a wooden cup, it rose 2.1°, and in the exhausted receiver 2.4°, and in air condensed to $1\frac{3}{4}$ atmospheres it rose 0.5°.

If these experiments should not be thought conclusive, there are others, which will not leave a doubt that the heat produced by friction is not connected with the decomposition of oxygen gas. Count Rumford contrived, with his usual ingenuity, to inclose the cylinder above described in a wooden box filled with water, which effectually excluded all air, as the cylinder itself and the borer were surrounded with water, and at the same time did not impede the motion of the instrument. The quantity of water amounted to 18.77lbs. avoirdupois, and at the beginning of the experiment was at the temperature of 60°. After the cylinder had revolved for an hour at the rate of 32 times in a minute, the temperature of the water was 107°; in 30 minutes more it was 178°; and in two hours and 30 minutes after the experiment began, the water actually boiled. According to the computation of Count Rumford, the caloric produced would have been sufficient to heat 26.58lbs. avoirdupois of ice-cold water boiling hot; and it would have required nine wax candles of a moderate size, burning with a clear flame all the time the experiment lasted, to have produced as much heat. In this experiment all access of water into the hole in the cylinder where the friction took place was prevented. But in another experiment, the result of which was precisely the same, the water was allowed free access.

The caloric then, which appears in consequence of friction, is neither produced by an increase of the density, nor by an alteration in the specific caloric of the substances exposed to friction, nor is it owing to the decomposition of the oxygen of the atmosphere. Whence then is it derived? This question cannot at present be answered: but this is no reason for concluding with count Rumford, that there is no such substance as caloric at all, but that it is merely a peculiar kind of motion; because other facts demonstrate the existence of caloric as a substance. Was it possible to prove that the accumulation of caloric by friction is incompatible with its being a substance, in that case count Rumford's conclusion would be a fair one; but this surely has not been done. We are certainly not yet sufficiently acquainted with the laws of the motion of caloric, to be able to affirm with certainty that friction cannot cause it to accumulate in the bodies rubbed. This we know at least to be the case with electricity. Nobody has been hitherto able to demonstrate in what manner it is accumulated by friction; and yet this has not been thought a sufficient reason to deny its existence.

Indeed there seems to be a very close analogy between caloric and electric matter. Both of them tend to diffuse themselves equally, both of them dilate bodies, both of them fuse metals, and both of them kindle combustible substances. See ELECTRICITY.

Mr. Achard has proved, that electricity can be substituted for caloric even in those cases where its agency seems peculiarly necessary; for he found that by constantly supplying a certain quantity of the electric fluid, eggs could be hatched just as when they are kept at the temperature of 103°. An accident indeed prevented the chickens from actually coming out, but they were formed and living, and within two days of bursting their shell. Electricity has also a great deal of influence on the heating and cooling of bodies. Mr. Pictet exhausted a glass globe, the capacity of which was 1200.199 cubic inches, till the manometer within it stood at 1.75 lines. In the middle of this globe was suspended a thermometer, which hung from the top of a glass rod fixed at the bottom of the globe, and going almost to its top. Opposite to the bulb of this thermometer two lighted candles were placed, the rays of which, by means of two concave mirrors, were concentrated on the bulb. The candles and the globe were placed on the same board, which was supported by a non-conductor of electricity. Two feet and a half from the globe there was an electrifying machine, which communicated with a brass ring at the mouth of the globe by means of a metallic conductor. This machine was kept working during the whole time of the experiment; and consequently a quantity of electric matter was constantly passing into the globe, which, in the language of Pictet, formed an atmosphere not only within it, but at some distance round, as was evident from the imperfect manner in which the candles burned. When the experiment began the thermometer stood at 49.8°. It rose to 70.2° in 732″. The same experiment was repeated, but no electric matter thrown in; the thermometer rose from 49.8° to 70.2° in 1050″; so that the electricity hastened the heating almost a third. In the first experiment the thermometer rose only to 71.3°, but in the second it rose to 77°. This difference was doubtless

owing to the candles burning better in the second than first experiment; for in other two experimects made exactly in the same manner, the maximum was equal both when there was and was not electric matter present. These experiments were repeated with this difference, that the candles were now insulated, by placing their candlesticks in vessels of varnished glass. The thermometer rose in the electrical vacuum from 52.2° to 74.7° in 1050″; in the simple vacuum in 965″. In tbe electrical vacuum the thermometer rose to 77°; in the simple vacuum to 86°. It follows from these experiments, that when the globe and the candles communicated with each other, electricity hastened the heating of the thermometer; but that when they were insulated separately, it retarded it. One would be apt to suspect the agency of electricity in the following experiment of Mr. Pictet: into one of the brass cups formerly described, a small quantity of cotton was put to prevent the bulb of the thermometer from being broken. As the cup turned round, two or three fibres of the cotton rubbed against the bulb, and without any other friction the thermometer rose five or six degrees. A greater quantity of cotton being made to rub against the bulb, the thermometer rose 15°.

FRIDSTOL, mentioned in our ancient writers among the immunities granted to churches, signifies a seat, chair, or place of peace and security, where criminals might find safety and protection: of these there were many in England, but the most famous was at Beverley, and that in St. Peter's church at York, granted by charter of king Henry I.

FRIEND, or Quaker. A society of dissenters from the church of England, obtained the latter appellation in the middle of the seventeenth century; the former they had before applied, and continue to apply, to themselves. The first preacher of this society was George Fox, a man of humble birth, and illiterate. The undertaking to which he considered himself called, that of promulgating a more simple and spiritual form of christianity than any of those which prevailed, and of directing the attention of christians to immediate Revelation, required little more reading than that of the Bible. A constant reference to the scriptures, with great zeal, courage, and perseverance, in preaching and suffering. did more than literature could have done, to spread his doctrine among the middle and lower classes. By those who treated religion scientifically, it was, with a few exceptions, more warmly opposed than sufficiently investigated. Arguments of civil coercion, of which the Friends bad a full, and from their stiffness more than a common share, have been found to recommend, instead of repressing dissent. A more liberal and laudable treatment of conscientious scruples has succeeded; and it may be now said, in a better sense, respecting religion, Sub judice lis est.

The most prominent feature in the Friends' view of christianity is this: seeing, no man knoweth the Father but the Son, and he to whomsoever the Son will reveal him, and seeing the revelation of the Son is in and by the Spirit; therefore the testimony of the Spirit is that alone by which the true knowledge of God is revealed. In this doctrine they agree in substance with the church of England, and all others who acknowledge the efficacy of grace. For in whatever way this is afforded to christians, it is powerfully given to know and to do the will of God; and the communication of grace may be termed, in strict consistency with the sense of the New Testament, a revelation of Christ in the Spirit. The Friends receive the Holy Scriptures as having proceeded from the revelations of the Holy Spirit; they account them the secondary rule for christians, subordinate to the word, and therefore not the word of God. According to these they profess their belief in one God, as Father, Word, and Holy Spirit; in one mediator, the word made flesh, Jesus Christ; in the conception, birth, life, miracles, death, resurrection, and ascension of Jesus; and in the remission of sins thereby purchased for the whole world of fallen mankind. Christ's redemption they believe to be perfected in us by his second coming in Spirit; in which they who obey him are, through the obedience of faith, restored from their state of alienation, and reconciled to God. They affirm, that for this end there is given to every man a measure of the light of Christ, (called by their early preachers the light within) a manifestation of the spirit to profit withal; which discovers sin, reproves for it, leads out of it, and if not resisted, will save from it, and lead on the christian to perfection. In public worship they profess to wait on God in this gift, in order to have their conditions made manifest, in silence and retirement of mind. They look for an extraordinary motion of it for vocal worship, and considering the qualification of a minister as a further gift which God confers, and of which the church ought to judge in the same spirit, they do not limit its exercise to any description of persons. They suffer some inconvenience hereby, as they acknowledge, but they prefer bearing this to the establishing of any form of worship, save the forementioned, waiting in silence. They do not baptize formally, or use the sign of the communion; they say the one has ceased as to obligation, and that the true administration of the other is by the spirit alone.

They deem it unlawful for christians to swear at all; and their affirmation in civil causes is made legal, instead of an oath. They refuse to "learn war or to lift up the sword," as well as to contribute directly to military proceedings. Yet as they inculcate implicit submission, actively or passively, to Cæsar, they neither resist nor evade the legal appropriation of their substance by him, as well to these as to ecclesiastical purposes. Against the claims of the clergy, as well as many other things apparently lawful, they say in their phraseology they have a testimony to bear.

Some peculiarities, well enough known, mark them out from their fellow citizens. Simplicity in dress, in some instances, nearly amounting to an adherence to their original, though not prescribed, costume; simplicity of language, *thou* to one person, and without compliments; simplicity in their manners of living; the non-observance of fasts and feasts; the rejection of those which they call the unchristian names of days and months; and the renunciation of the theatres and other promiscuous amusements, gaming, and the usual outward signs of mourning and rejoicing, may be considered as their Shibboleth.

They marry among themselves by a ceremony or contract, religiously conducted. and bury their dead in the most simple manner. They maintain their poor, and enforce their own rules, by means of an excellent system of discipline, founded by G. Fox. They receive ap-

proved applicants into their society by an act of monthly meeting, or particular congregation, and without subscription of articles. They disown in the same manner, after repeated admonition, not officially only, but actually extended, to offenders against morality, or their peculiar rules. The latter may be seen in a book entitled, "Extracts from the Minutes and Advices of the Yearly Meeting of Friends, held in London, from its first institution:" their principles and doctrines in Barclay's Apology, and their history in a large work by William Sewel.

FRIEZE, FREEZE, or FRIZE. See ARCHITECTURE.

FRIGATE, among seamen, a ship of war, light built, and that is a good sailer. A frigate has commonly two decks, whence that called a light frigate is a frigate with only one deck. All ships of war that carry from 20 guns to 50 guns are called frigates.

FRIGATOON, a Venetian vessel, commonly used in the Adriatic sea, with a square stern, and carrying only a mainmast, mizen, and bowsprit.

FRILAZIN, the name of a class or rank of people among the Anglo-Saxons, consisting of those who had been slaves, but had either purchased, or by some other means obtained, their liberty. Though these were in reality free men, they were not considered as of the same rank and dignity with those who had been born free, but were still in a more ignoble condition, and dependent either on their former masters or on some new patrons. This custom the Anglo Saxons seem to have derived from their ancestors in Germany, among whom those who had been made free did not differ much in point of dignity or importance in the state from those who continued in servitude. This distinction between those who have been made free, and those who enjoy freedom by descent from a long race of free men, still prevails in many parts of Germany; and particularly in the original seats of the Anglo-Saxons. Many of the inhabitants of towns and cities in England, in this period, seem to have been of this class of men, who were in a kind of middle state between slaves and freemen.

FRINGELLA, in ornithology, a genus belonging to the order of passeres. The bill is conical, straight, and sharp-pointed. There are no less than 108 species comprehended under this genus, distinguished principally by varieties in their colour. The following are the most remarkable.

1. The carduelis, or goldfinch, with the quill feathers red forwards, and the outermost without any spots; the two outermost are white in the middle, as the rest are at the point. The young bird, before it moults, is grey on the head; and hence it is termed by the bird-catchers a grey-pate. There is a variety of goldfinches called by the London bird-catchers a cheverel, from the manner in which it concludes its jerk. It is distinguished from the common sort by a white streak, or by two, sometimes three, white spots under the throat. The note of the goldfinch is very sweet, and they are much esteemed on that account, as well as for their great docility. Towards winter, they assemble in flocks, and feed on seeds of different kinds, particularly those of the thistle. They are fond of orchards, and frequently build in an apple or pear-tree; the nest is very elegantly formed of fine moss, liverworts, and bents, on the outside; lined first with wool or hair, and then with the goslin or cotton of the sallow. The goldfinch lays five white eggs, marked with deep purple spots on the upper end, and has two broods in the year. When kept in cages, they are commonly fed much on hemp-seed, which they eat freely, but which is said to make them grow black, and lose both their red and yellow. The goldfinch is a long-lived bird, often attaining the age of 20 years. This species is numerous throughout Europe; it is also met with both in Asia and Africa, but less common in those countries.

2. The cælebs, or chaffinch, has black limbs, and the wings white on both sides; the three first feathers of the tail are without spots, but two of the chief are obliquely spotted. It has its name from delighting in chaff. This species entertains us agreeably with its song very early in the year, but towards the end of the summer assumes a chirping note. Both sexes continue with us the whole year. What is very singular in Sweden, the female quits that country in September, migrating in flocks into Holland, leaving their mates behind: in the spring they return. In Hampshire Mr. White has observed sometimes vast flocks of females with scarcely any males among them. Their nest is as elegantly constructed as that of the goldfinch, and of much the same materials, only the inside has the addition of some large feathers. They lay four or five eggs of a dull white colour, tinged and spotted with deep purple. They are caught in plenty in flight-time.

3. The montifringilla, or brambling, has a yellow bill tipt with black; the head, hind part of the neck, and back, are black; the throat, fore part of the neck, and breast, pale rufous orange; lower part of the breast and belly white; the quill feathers brown, with yellowish edges; the tail a little forked; the legs grey. This species migrates into England at certain seasons, but does not build there. It is frequently found among chaffinches, and sometimes comes in vast flocks. They are also seen at certain times in vast clouds in France, insomuch that the ground has been quite covered with their dung, and more than 600 dozen were killed each night. They are said to be particularly fond of beech mast, but will also eat seeds of various other kinds. Their flesh is eaten by many, but is apt to prove bitter. They are said to breed about Luxemburgh, making their nests on the tall fig-trees, composed of long moss without, and lined with wool and feathers within; the eggs are four or five in number, yellowish, and spotted; and the young are fledged at the end of May. This species is found more or less throughout Europe, and is common in the pine forests of Russia and Siberia, but those of the last are darker in colour and less in size.

4. The domestica, or sparrow, has the prime feathers of the wings and tail brown, the body variegated with grey and black, and a single white streak on the wings. These well-known birds are proverbially salacious, and have three broods in a year. They are every where common about our houses, where they build in every place they can find admittance to; under the roof, at the corner of the brick-work, or in holes of the wall. They make a slovenly nest; generally a little hay ill put together, but lined well with feathers, where they lay five or six eggs of a reddish white colour spotted with brown. They will sometimes build in the neighbouring trees, in which case they take more pains with the nest; and not

unfrequently they expel the martins from theirs, to save the trouble of constructing one of their own. The sparrow, from frequenting only habitations and parts adjacent, may be said to be chiefly fed from human industry; for, in spite of every precaution, it will partake with the pigeons, poultry, &c. in the food thrown out to them, grain of all kinds being most agreeable to its taste, though it will eat refuse from the kitchen of most kinds. It is a familiar but crafty bird, and will not so easily come into a snare as many others. In autumn they often collect into flocks, and roost in numbers on the neighbouring trees, when they may be shot by dozens, or at night caught in great numbers by a bat fowling-net.

5. The spinus, or siskin, has the prime feathers of the wings yellow in the middle, and the four first chief tail-feathers without spots; but they are yellow at the base, and black at the points. Mr. Willoghby tells us, that this is a song-bird; that in Sussex it is called the barley-bird, because it comes to them in barley-seed time. We are informed that it visits these islands at very uncertain times, like the gross-beak, &c. It is to be met with in the bird-shops in London; and being rather a scarce bird, sells at a higher price than the merit of its song deserves: it is known there by the name of the aberdavine. It is a very tame and docile species, and is often kept and paired with the Canary-bird, with which it breeds freely. The bird-catchers have a notion of its coming out of Russia. Dr. Kramer informs us, that this bird conceals its nest with great art; and though there are infinite numbers of young birds in the woods on the banks of the Danube, which seem just to have taken flight, yet no one could discover the nest.

6. The linota, or linnet, has the bottom of the breast of a fine blood-red, which heightens as the spring advances. These birds are much esteemed for their song. They feed on seeds of different kinds, which they peel before they eat; the seed of the linum or flax is their favourite food; whence the name of the linnet tribe. They breed among furze and white thorn; the outside of their nest is made with moss and bents, and lined with wool and hair. They lay five whitish eggs, spotted like those of the goldfinch.

7. The cannabina, or greater red-pole, is less than the common linnet, and has a blood-coloured spot on the forehead, and the breast of the male is tinged with a fine rose-colour. It is a common fraud in the bird-shops in London, when a male bird is digtinguished from the female by a red-breast, as in the case of this bird, to stain or paint the feathers, so that the deceit is not easily discovered, without at least close inspection. These birds are frequent on the coasts of Britain, and are often taken in flight-time near London: it is a familiar bird, and is chereful in five minutes after it is caught.

8. The linaria, or lesser red-pole, is about half the size of the last, with a rich spot of purplish red on the forehead; the breast is of the same colour, but less bright. Mr. Pennant mentions an instance of this bird being so tenacious of her nest, as to suffer herself to be taken off by the hand, and that when released she would not forsake it. This species is known about London by the name of stone red-pole. Linnæus, Kramer, and others, mention its being very fond of the seeds of alder. Whole flocks of them, mixed with the siskin, frequent places where alders grow, for the sake of picking the catkins: they generally hang like the titmouse, with the back downwards; and in this state are so intent on their work, that they may be entangled one after another by dozens, by means of a twig, smeared with bird-lime, fastened to the end of a fishing-rod or other long pole. This species seems to be in plenty throughout Europe, from the extreme parts of Russia on the one hand to Italy on the other; is very common in Greenland, and was also met with by our late voyagers at Aoonalashka. In America it is likewise well known. Hence it seems to be a bird common to the whole of the northern part of the globe without exception.

9. The montium, or twite, is about the size of a linnet. It has the feathers of the upper part of the body dusky, those on the head edged with ash-colour, the others with brownish red: the rump is pale crimson; the wings and tail are dusky, the tips of the greater coverts and secondaries whitish; the legs pale brown. The female wants the red mark on the rump. Twites are taken in the flight-season near London, along with other linnets. It is probable that the name has been taken from their twittering note, having no music in it; and indeed the bird-catchers will tell, at some distance, whether there are any twites mixed among linnets merely from this circumstance. The twite is supposed to breed in the more northern parts of England.

10. The amandava, or amaduvade bird, is about the size of a wren. The colour of the bill is of a dull red; all the upper parts are brown, with a mixture of red: the under the same, but paler, the middle of the belly darkest; all the feathers of the upper wing-coverts, breast, and sides, have a spot of white at the tip: the quills are of a grey brown; the tail is black, and the legs are of a pale yellowish white. It inhabits Bengal, Java, Malacca, and other parts of Asia.

11. The senagala, or Senegal finch, is a species very little larger than a wren. The bill is reddish, edged all round with brown, and beneath the under mandible a line of brown quite to the tip: the same also is seen on the ridge of the upper mandible; the upper parts of the body are of a vinaceous red colour; the lower parts, with the thighs and under tail-coverts, of a greenish brown; the hind part of the head and neck, the back, scapulars, and wing-coverts, are brown; the tail is black; and the legs are pale grey. It inhabits Bengal; and, with the former species, feeds on millet. This affords the natives an easy method of catching them: they have no more to do than to support a large hollowed gourd, the bottom uppermost, on a stick, with a string leading to some covered place, and strewing under it some millet; the little birds, hastening in numbers to pick it up, are caught beneath the trap, by the stick being pulled away by the observer at a distance. The females are said to sing nearly as well as the males. They are familiar birds; and when once used to the climate, will frequently live five or six years in a cage. They have been bred in Holland by the fanciers of birds. See Plate LX. Nat. Hist. fig. 209.

12. The canaria, or canary-bird, has a whitish body and bill, with the prime feathers of the wings and tail greenish. It was originally peculiar to those islands to which it owes its name; the same that were known to

the ancients by the addition of the Fortunate. Though the ancients celebrate the island of Canaria for the multitude of birds, they have not mentioned any in particular. It is probable then, that this species was not introduced into Europe till after the second discovery of these islands, which was between the 13th and 14th centuries. We are uncertain when it first made its appearance in that quarter of the globe. Belon, who wrote in 1555, is silent in respect to these birds; Gesner is the first who mentions them; and Aldrovand speaks of them as rarities, observing that they were very dear, on account of the difficulty attending the bringing them from so distant a country, and that they were purchased by people of rank alone. They are still found on the same spot to which we were first indebted for the production of such charming songsters; but they are now become so very numerous, that we are under no necessity of crossing the ocean for them. The canary-bird will prove fertile with the siskin and goldfinch; but in this case the produce, for the most part, proves sterile: the pairs succeed best when the hen-bird is the canary, and the cock of the opposite species. It will also prove prolific with the linnet, yellow-hammer, chaffinch, and even the house sparrow; but the male canary-bird will not assimilate with the female of these birds; the hen must be ever of the canary species, and the young of these mostly prove male birds. This bird is said by some to live 10 or 15 years; by others as far as 18.

13. The maja, or cubafinch, is about three and one quarter inches long, is found in Cuba, and feeds principally on rice. See Plate LX. Nat. Hist. fig. 210.

FRIT, or Fritt, in the glass manufacture, is the matter or ingredients of which glass is to be made, when they have been calcined or baked in a furnace. A salt drawn from the ashes of the plant kali or from fern, or other plants, mixed with sand or flint, and baked together, makes an opaque mass, called by glass-men frit; probably from the Italian frittare, to fry; or because the frit when melted runs into lumps, like fritters, called by the Italians fritelli. Frit by the ancients was called ammonitrum, from ἁμμ, sand, and νιτρον, nitre; under which name it is described by Pliny thus: Fine sand from the Volturnian sea, mixed with three times the quantity of nitre, and melted, makes a mass called ammonitrum; which being rebaked makes pure glass. Frit, Neri observes, is only the calx of the materials which makes glass; which, though they might be melted, and glass be made without thus calcining them, yet it would take up much more time. This calcining, or making of frit, serves to mix and incorporate the materials together, and to evaporate all the superfluous humidity. The frit, once made, is readily fused and turned into glass.

There are three kinds of frit: the first crystal frit, or that for crystal or clear glass, is made with salt of pulverine and sand. The second and ordinary frit is made of the bare ashes of pulverine or barilla, without extracting the salt from them. This makes the ordinary white or crystal glass. The third is frit for green glasses, made of common ashes, without any preparation. This last frit will require 10 or 12 hours baking. The materials in each are to be finely powdered, washed, and searced; then equally mixed, and frequently stirred together in the melting pot.

FRITH, in its most usual acceptation, signifies an arm of the sea: such are the frith of Forth or of Edinburgh, the frith of Clyde, Murray frith, &c.

FRITILLARIA, fritillary, a genus of the monogynia order, in the hexandria class of plants, and in the natural method ranking under the 10th order, coronariæ. The corolla is hexapetalous and campanulated, with a nectariferous cavity above the heel in each petal; the stamina are as long as the corolla. There are five species, all of them bulbous-rooted flowery perennials, producing annual stalks from about one foot to a yard or more high, terminated by large, bell-shaped, liliaceous flowers, of a great variety of colours. They are all propagated by offsets, which they furnish abundantly from the sides of the roots, and which may be separated every second or third year; they are hardy plants, and will thrive in any of the common borders. The crown-imperial is well known.

FRIZING *of cloth*, a term in the wollen manufactory, applied to the forming of the nap of cloth or stuff into a number of little hard burrs or prominences, covering almost the whole ground.

Some cloths are only frized on the back-side, as black cloths; others on the right side, as coloured and mixed cloths, rateens, bays, freezes, &c. Frizing may be performed two ways: one with the hand, that is, by means of two workmen, who conduct a kind of plank that serves for a frizing instrument. The other way is by a mill, worked either by water or a horse, or sometimes by men. This latter is esteemed the better way of frizing, the motion being uniform and regular, the little knobs of the frizing are formed more equably and regularly. The structure of this useful machine is as follows:

The three principal parts are the frizer or crisper, the frizing-table, and the drawer or beam. The two first are two equal planks or boards, each about 10 feet long, and 15 inches broad, differing only in this, that the frizing-table is lined or covered with a kind of coarse woollen stuff, of a rough sturdy nap; and the frizer is incrustated with a kind of cement composed of glue, gum arabic, and a yellow sand, with a little aqua vitæ or urine. The beam or drawer, thus called because it draws the stuff from between the frizer and the frizing-table, is a wooden roller, beset all over with little, fine, short points, or ends of wire, like those of cards used in carding of wool.

The disposition and use of the machine is thus: The table stands immoveable, and sustains the cloth to be frized, which is laid with that side uppermost on which nap is to be raised: over the table is placed the frizer, at such a distance from it as to give room for the stuff to be passed between them, so that the frizer, having a very slow semicircular motion, meeting the long hairs or naps of the cloth, twists and rolls them into little knobs or burrs, while at the same time the drawer, which is continually turning, draws away the stuff from under the frizer, and winds it over its own points.

All that the workman has to do while the machine is going, is to stretch the stuff on the table as fast as the drawer takes it off: and from time to time to take off the stuff from the points of the drawer. The design of [illegible]ing the frizing-table [illegible] with stuff of a [illegible]

stubby nap, is that it may detain the cloth between the table and the frizer long enough for the grain to be formed, that the drawer may not take it away too readily, which must otherwise be the case, as it is not held by any thing at the other end. It is unnecessary to say any thing particular of the manner of frizing stuffs with the hand, it being the aim of the workmen to imitate as near as they can, with their wooden instrument, the slow, equable, and circular motion of the machine: it needs only be added, that their frizer is but about two feet long and one broad; and that, to form the nap more easily, they moisten the surface of the stuff lightly with water mingled with whites of eggs or honey.

FROG. See RANA.

FROG-FISH of Surinam, a very singular animal, of which there is no specimen in the British or any public museum. In Surinam these fishes are called jakjés. They are cartilaginous, of a substance like our mustela, and exquisite food: they are formed with regular vertebræ, and small bones all over the body divided into equal parts; are first darkish, and then grey; their scales make a beautiful appearance. Whether this animal is, in its perfect state, a species of frog with a tail, or a kind of water-lizard, Mr. Edwards does not pretend to determine, but observes, that when its size is considered, if it should be deemed a tadpole at first produced from spawn and in its progress towards a frog, such an animal, when full grown, if it bears the same proportion to its tadpole as those in Europe do, must be of enormous size; for our full-grown frogs exceed the tadpoles at least 50 times.

FRONT *of a battalion*, among military men, is the first rank, or file-leaders. It is likewise called the face or head of the battalion.

FRONTAL, or FRONTLET, or BROWBAND, is used in speaking of the Jewish ceremonies. It consists of four several pieces of vellum, on each whereof is written some text of scripture: they are all laid on a piece of calf's leather, with thongs to tie it by.

The Jews apply the leather with the velum on their foreheads in the synagogue, and tie it round the head with the thongs.

FRONTAL MUSCLES. See ANATOMY.

FRONTIS os, in anatomy, called also os coronale, the bone of the forehead. See ANATOMY.

FROST. See COLD and FREEZING.

FROTH-SPIT, or CUCKOW-SPIT, a name given to a white froth or spume, very common in the spring. It forms the nidus of a species of cicada.

FRUCTIFICATION. See BOTANY.

FRUIT. Every person who shall bark any fruit-tree, shall forfeit to the party grieved treble damages by action at the common law, and also 10*l.* to the king. 37 H. VIII. c. 6.

Every person who shall rob any orchard or garden, or dig or pull up any fruit-trees, with intent to take the same away (the same not being felony by the laws of England), shall, on conviction before one justice, give to the party such satisfaction for damages as such justices shall appoint; and in default of payment to be whipped. 43 Eliz. c. 7.

And with respect to what shall be deemed felony by the laws of England, the distinction seems to be, that if they are any way annexed to the freehold, as trees growing, or apples growing upon the trees, then the taking and carrying them away is not felony but trespass only, for a man cannot steal part of a freehold; but if they are severed from the freehold, as wood cut or apples gathered from the trees, then the taking of them is not a trespass only, but felony. Id.

Fine and imprisonment may be inflicted on persons destroying fruit-trees. 1 Geo. I. c. 48.

Robbing orchards or gardens of fruit growing therein, may be punished by fine, whipping, &c.

FRUIT-TREES. See GARDENING.

FRUMENTARII, a kind of soldiers or archers, under the western empire. The first time we read of these officers is in the time of the emperor Adrian, who made use of them to inform himself of whatever passed. They did not make any particular corps distinct from the rest of the forces, but there was a certain number of them in each legion. It is supposed that they were at first a number of young persons disposed by Augustus, throughout the provinces, particularly on all the grand roads, to acquaint the emperor, with all expedition, of every thing that happened.

FRUMENTATION, in Roman antiquity, a largess of corn bestowed on the people. This practice of giving corn to the people was very ancient among the Romans, and frequently used to sooth the turbulent humour of the populace. At first the number of those to whom this largess was given was indeterminate, till Augustus fixed it at two hundred thousand.

FRUSTUM, in mathematics, a part of some solid body separated from the rest.

The frustum of a cone is the part that remains, when the top is cut off by a plane parallell to the base, and is otherwise called a truncated cone: for finding the surface and solidity of which, see GEOMETRY and MENSURATION.

The frustum of a globe or sphere is any part of it cut off by a plane, the solid contents of which may be found by this rule. To three times the square of the semidiameter of the base add the square of its height; then multiplying that sum by the height, and this product multiplied by .5236, gives the solidity of the frustum.

A frustum or portion of any solid, generated by the revolution of any conic section upon its axis, and terminated by any two parallel planes, may be thus compared to a cylinder of the same altitude, and whose base is equal to the middle section of the frustum made by a parallel plane. 1. The difference between such frustum and cylinder is always the same in different parts of the same or of similar solids; when the inclination of the planes to the axis, and the altitude of the frustum are given. 2. In the parabolic conoid, this difference vanishes; the frustum being always equal to a cylinder of the same height, upon the section of the conoid that bisects the altitude of the frustum, and is parallel to its basis. 3. In the sphere, the friction is always less than the cylinder by one fourth part of a right-angled cone of the same height with the frustum, or, by one half of a sphere, of a diameter equal to that height: and this difference is always the same in all spheres whatever, when this altitude of the frustum is given. 4. In the cone the frustum always exceeds the cylinder by one fourth part of the

content of a similar cone, that has the same height with the frustum.

FUCHSIA, a genus of plants of the octandria monogynia class and order. The calyx is one-leafed, coloured, bearing; the corolla very large; petals four, small. Berry inferior, four-celled, many seeds. There are five species, of which the fuchsia coccinea is very beautiful, and is now a common plant, though only introduced in 1788 from Chili. It will live in the open ground, though the stem will then die off annually. In the greenhouse it is a shrub, as are all the other species.

FUCUS, a name given by the ancients to certain dyes and paints. By this name they called a purple sea-plant used by them to dye woollen and linen cloths of that colour. The dye was very beautiful, but not lasting; for it soon began to change, and in time went wholly off. This is the account Theophrastus gives of it.

The women of those times also used something called fucus to stain their cheeks red; and many have supposed, from the same word expressing both, that the same substance was used on both occasions. But this, on a strict inquiry, proves not to be the case. The Greeks called every thing fucus that would stain or paint the flesh. But this peculiar substance, used by the women to paint their cheeks, was distinguished from the others by the name of rizion among the more correct writers, and was indeed a root brought from Syria into Greece. The Latins, in imitation of the Greek name, called this root radicula; and Pliny very erroneously confounds the plant with the radix lunaria, or struthion of the Greeks.

The word fucus was in these times become such an universal name for paint, that the Greeks and Romans had a fucus mellicus, which was the cerus used for painting the neck and arms white; after which they used the purpurissum, or red fucus of the rizium, to give the colour to the cheeks. In aftertimes they also used a peculiar fucus or paint, for the purpose, prepared of the cretal argentaria or silverchalk, and some of the rich purple dyes that were in use at that time: and this seems to have been very little different from our rosepink, a colour commonly sold at the colour-shops.

Fucus, in the Linnæan system of botany, is a genus of the order of algæ, belonging to the cryptogamia class of plants. The most remarkable species are,

1. The serrantus, serrated fucus, or sea-wrack. This is frequent at all seasons of the year upon the rocks at low-water-mark, but produces its seeds in July and August. It consists of a flat, radical, and dichotomous leaf, about two feet long; the branches half an inch wide, serrated on the edges with dents of unequal size, and at unequal distances, having a flat stalk or rib divided like the leaf, and running in the middle of it through all its various ramifications. A small species of coralline, called by Linnæus certularia pumila, frequently creeps along the leaf. All the species of fucus afford a quantity of impure alkaline salts; but this much less than some others, eight ounces of the ashes yielding only three of fixed salt. The Dutch cover their crabs and lobsters with this fucus, to keep them alive and moist, and prefer it to any other, as being destitute of those mucous vesicles with which some of the rest abound, and which would sooner ferment and become putrid.

2. The vesiculosus, bladder fucus, common sea-wrack, or sea-ware. It grows in great abundance on the sea-rocks about low-water-mark, producing its fructifications in July and August. It has the same habit, colour, and substance as the foregoing, but differs from it in the following respects: the edges of the leaf have no serratures, but are quite entire. In the disc or surface are immersed hollow, spherical, or oval air-bladders, hairy within, growing generally in pairs, but often single in the angles of the branches, which are most probably air-bladders destined to buoy up the plant in the water. Lastly, on the summits or extreme segments of the leaves appear tumid vesicles about three quarters of an inch long, sometimes oval and in pairs, sometimes single and bifid, with a clear viscid mucus interspersed with downy hairs. This species is an excellent manure for land; for which purpose it is often applied in the maritime parts of Scotland and other countries. In the islands of Jura and Skye it frequently serves as a winter food for cattle, which regularly come down to the shores at the recess of the tides to seek for it. And sometimes even the stags have been observed, after a storm, to descend from the mountains to the sea-sides to feed upon this plant.

Linnæus informs us, that the inhabitants of Gothland in Sweden boil this fucus in water, and, mixing with it a little coarse meal or flour, feed their hogs with it; for which reason they call the plant swinetang. And in Scania, he says, the poor people cover their cottages with it, and sometimes use it for fuel. In Jura, and some other of the Hebrides, the inhabitants dry their cheeses without salt, by covering them with the ashes of this plant, which abounds with such a quantity of salts, that from five ounces of the ashes may be procured two ounces and a half of fixed alkaline salts, that is, half to their whole weight. But the most beneficial use to which the fucus vesiculosus is applied, in the way of economy, is in making pot-ash or kelp, a work much practised in the Western Isles. There is great difference in the goodness and price of this commodity, and much care and skill required in properly making it. That is esteemed the best which is hardest, finest grained, and free from sand or earth. The price of kelp in Jura is 3*l.* 10*s.* per ton, and about 40 or 50 tons are exported annually from that island. So great a value is set upon this fucus by the inhabitants of that place, that they have sometimes thought it worth their while to roll fragments of rocks and huge stones into the sea, in order to invite the growth of it.

Its virtues in the medical way have been much celebrated by Dr. Russel, in his Dissertation concerning the use of Sea-water in the Diseases of the Glands. He found the saponaceous liquor or mucus in the vesicles of this plant to be an excellent resolvent, extremely serviceable in dispersing all scorbutic and scrophulous swellings of the glands. He recommends the patient to rub the tumour with these vesicles bruised in his hand, till the mucus has thoroughly penetrated the part, and afterwards to wash with sea water. Or otherwise, to gather two pounds of the tumid vesicles, in the month of July, when they are full of mucus, and infuse them in a quart of sea water, in a glass vessel, for the space of 15 days, when the liquor will have acquired nearly the consistence of honey. Then strain it off through a linen cloth,

and rub this liquor with the hand, as before, three or four times a day, upon any hard or scrophulous swellings, washing the parts afterwards with sea water; and nothing can be more efficacious to disperse them. Even scirrhosities, he says, in women's breasts, have been dispelled by this treatment. The same author, by calcining the plant in the open air, made a very black salt powder, which he called vegetable æthiops; a medicine much in use as a resolvent and deobstruent, and recommended also as an excellent dentrifice to correct the scorbutic laxity of the gums, and to take off the foulness of the teeth.

3. The plicatus, matted or Indian-grass fucus, grows on the sea-shores in many places both of England and Scotland. It is generally about three or four, but sometimes six, inches long. Its colour, after being exposed to the sun and air, is yellowish or auburn; its substance pellucid, tough, and horney, so as to bear a strong resemblance to what anglers call Indian-grass, that is, the tendrils issuing from the ovary of the dog-fish.

4. The palmatus, palmated or sweet fucus, commonly called dulse or dilse. This grows plentifully on the sea-coasts of Scotland and the adjoining islands. Its substance is membranaceous, thin, and pellucid; the colour red; sometimes green with a little mixture of red; its length generally about five or six inches, but varies from three inches to a foot; its manner of growth fan-shaped, or gradually dilated from the base upwards. Its divisions are extremely various. The inhabitants both of Scotland and England take pleasure in eating this plant, without expecting any medical virtues from it. The inhabitants of the Archipelago also are fond of it, as we learn from Steller. They sometimes eat it raw, but esteem it most when added to ragouts, oglios, &c. to which it gives a red colour, and, dissolving, renders them thick and gelatinous. In the isle of Skye it is sometimes used in fevers to promote a sweat, being boiled in water with the addition of a little butter. In this manner it also frequently purges. The leaves, infused in water, exhale a scent like that of dried violets.

5. The esculentus, eatable fucus, or bladder-locks, commonly called tangle in Scotland, is likewise a native of the British shores. It is commonly about four feet long, and seven or eight inches wide; but is sometimes found three yards or more in length, and a foot in width. Small specimens are not above a cubit long, and two inches broad. The substance is thin, membranaceous, and pellucid; the colour green or olive. The root consists of tough cartilaginous fibres. The stalk is about six inches long, and half an inch wide, nearly square, and pinnated in the middle between the root and origin of the leaf, with ten or a dozen pair of thick, cartilaginous, oval-obtuse, foliaceous ligaments, each about two inches long, and crowded together. The leaf is of an oval-lanceolate, or long elliptic form, simple and undivided, waved on the edges, and widely ribbed on the middle from bottom to top, the stalk running through its whole length, and standing out on both sides of the leaf. This fucus is eaten in the north both by men and cattle. Its proper season is in the month of September, when it is in the greatest perfection. The membranous part is rejected, and the stalk only is eaten. It is recommended in the disorder called pica, to strengthen the stomach and restore the appetite.

6. The saccharinus, sweet fucus, or sea-belt, is very common on the sea-coast. The substance of this is cartilaginous and leathern, and the leaf is quite ribless. By these characters it is distinguished from the preceding, to which it is nearly allied. It consists only of one simple, linear, elliptic leaf, of a tawny green colour, about five feet long, and three inches wide in its full-grown state, but varies so exceedingly as to be found from a foot to four yards in length. The ordinary length of the stalk is two inches; but it varies even to a foot. The root is composed of branched fibres, which adhere to the stones like claws. This plant is often infested with the sertularia ciliata. The inhabitants of Iceland make a kind of pottage of this fucus, boiling it in milk, and eating it with a spoon. They also soak it in fresh water, dry it in the sun, and then lay it up in wooden vessels, where in a short time it is covered with a white efflorescence of sea-salt, which has a sweet taste like sugar. This they eat with butter; but if taken in too great a quantity, the salt is apt to irritate the bowels, and bring on a purging. Their cattle feed and get fat upon this plant, both in its recent and dry state; but their flesh acquires a bad flavour. It is sometimes eaten by the common people on the coast of England, being boiled as a pot-herb.

7. The ciliatus, ciliated or ligulated fucus, is found on the shores of Iona and other places, but is not common. The colour of this is red, the substance membranous and pellucid, without rib or nerve; the ordinary height of the whole plant about four or five inches. It is variable in its appearance, according to the different stages of its growth. This fucus is eaten by the Scots and Irish promiscuously with the fucus palmatus or dilse.

8. The prolifer, or proliferous fucus, is found on the shores of the western coast, adhering to shells and stones. The colour is red; the substance membranaceous, but tough, and somewhat cartilaginous, without rib or nerve, though thicker in the middle than at the edges. The whole length of the plant is about four or five inches, the breadth of each leaf about a quarter of an inch. The growth of this fucus, when examined with attention, appears to be extremely singular and wonderful. It takes its origin either from a simple, entire, narrow, elliptic leaf, about an inch and a half long; or from a dilated forked one of the same length. Near the extremity of the elliptic leaf, or the points of the forked one (but out of the surface, and not the edge), arises one or more elliptic or forked leaves, which produce other similar ones in the same manner near the summits; and so on continually one or more leaves from near the ends of each other, in a proliferous and dichotomous order, to the top of the plant, which in the manner of its growth resembles in a good measure the cactus opuntia, or flat-leaved Indian fig. Sometimes two or three leaves or more grow out of the middle of the disc of another leaf; but this is not the common order of their growth. The fructifications are red, spherical, rough warts, less than the smallest pin's head, scattered without order on the surface of the leaves. These warts, when highly magnified, appear to be the curled rudiments of young leaves, which in due time either drop off and form new plants, or continue on and germinate upon the parent. This plant is

very much infested with the flustra pilosa, the mandrepora verrucaria, and other corallines, which make it appear as if covered with scabs.

9. The pinnatifidus, jagged fucus, or pepper-dilse, is frequent on sea-rocks which are covered by the tides both on the eastern and western coasts. It is of a yellow olive-colour, often tinged with red. The substance is cartilaginous, but yet tender and transparent; the height about two or three inches. This fucus has a hot taste in the mouth, and is therefore called pepper-dilse by the people in Scotland, who frequently eat it as a salad, in the same manner they do the fucus palmatus.

10. The plocamium, or pectinated fucus, is frequent on the sea-rocks, and in basins of water left by the recess of the tides. Its natural colour is a most beautiful bright red or purple, but is often variegated with white or yellow. Its substance is cartilaginous, but extremely thin, delicate, and transparent; its height commonly about three or four inches. The stalk is compressed, about half a line in diameter, erect, but waved in its growth, and divided almost from the base into many widely-expanded branches. These primary branches are very long, alternate, exactly like the stalk, and subdivided into alternate secondary branches, which are again frequently compounded in like manner, and these divisions decorated with subulated teeth growing in alternate rows, curiously pectinated or finely toothed on the upper side like a comb, the smallest of these teeth scarcely visible to the naked eye. The fructifications are minute spherical capsules, or smooth dark-red globules, scattered without order on the sides of the branches, generally sessile, but some few of them supported on short peduncles. This fucus, on account of its elegant colours and fine divisions, is the species most admired by the ladies who are fond of pictures and mimic landscapes composed of marine vegetables.

11. The filum, thread-fucus, or sea-laces, is found on the sea-rocks, and waving under the water like long strings, frequent on many parts of the coast. The substance of this is opaque and cartilaginous, but not difficult to be broken. The colour, when recent, a dull olive-green; when dry, fuscous or nearly black; and, when exposed for some time on the shores to the sun and air, it becomes yellow, straw-coloured, or white. It consists only of a simple, unbranched, naked, cylindrical stalk, three or four yards long, more or less, from the size of a large fiddle-string to that of a thick whip-cord; smallest at the base and summit, smooth on the outside, full of mucus within, often twisted. and always intercepted by numerous transverse diaphragms, visible when the plant is held between the eye and the light. The fructifications have not yet been discovered; but from the transverse septa in its structure, it is reasonable to suppose this plant to belong rather to the genus of conferva than that of fucus. The stalks, skinned when half dry, and twisted, acquire so considerable a degree of strength and toughness, that we are informed the Highlanders sometimes use them for the same purpose as Indian-grass.

12. The giganteus, or gigantic fucus, is a native of the Straits Le Maire, and grows on rocky ground, which in those countries is distinguished from sand or ooze by the enormous length of the sea-weeds that grow upon it. The leaves are four feet long, and some of the stalks, though not thicker than a man's thumb, are 120. Sir Joseph Banks and Dr. Solander sounded over some of them which were 84 feet long; and as they made a very acute angle with the bottom, they were thought to be at least one half longer.

FUEL. All faggots made for sale, shall contain in compass, besides the knot of the bond, 24 inches of assize; and every faggot-stick within the bond shall contain full three feet of assize, except only one stick to be but one foot long, to stop or harden the binding. 43 Eliz. c. 14.

All billets (except those made of beech) that lie exposed in the public places, where they are usually bought or sold, shall be assized and cut as directed by 9 Anne, c. 15.

FUGAM FECIT, is where it is found by inquisition that a person fled for treason or felony; as to which it is agreed, that wheresoever a person found guilty by such inquest, either as a principal or as an accessary before the fact, is found also to have fled for the same, he forfeits his goods absolutely, and the issues of his lands, till he is pardoned or acquitted.

But wherever the indictment against a man is insufficient, the finding a fugam fecit will not hurt him; and that in all cases the particulars of the goods found to be forfeited may be traversed. 2 Haw. 450.

FUGITIVE'S GOODS, are the proper goods of him that flies, which after the flight lawfully found, belong to the king or lord of the manor. 5 Co. Rep. 109. See FELON'S GOODS.

FUGUE, in music, a term derived from the Latin word fuga, a flight, and signifying a composition either vocal or instrumental, or both, in which one part leads off some determined succession of notes called the subject, which, after being answered in the fifth and eighth by the other parts, is interspersed through the movement, and distributed amid all the parts in a desultory manner, at the pleasure of the composer; sometimes accompanied by other adventitious matter, and sometimes by itself. There are distinct descriptions of fugues; the simple fugue, the double fugue, and the counter fugue. The

Simple FUGUE contains but one subject, is the least elaborate in its construction, and the easiest in its composition.

Double FUGUE, consists of two subjects, occasionally intermingled and moving together; and the

Counter FUGUE, is that fugue in which the subjects move in a direction contrary to each other. In all the different species of fugues, the parts fly, or run after each other, and hence the derivation of the general name fugue.

FULCRUM, in mechanics, the prop or support by which a lever is sustained. See MECHANICS.

FUIRENA, a genus of the triandria monogynia class and order. The ament is imbricate; calyx none; corolla with three petal-shaped orbicular glumes, ending in a tendril. There is one species, a grass of Surinam.

FULGORA, or lantern-fly, an insect belonging to the hemiptera order. The generic character is: head produced into an inflated hollow front; antennæ beneath the eyes, of two joints, the exterior larger and globose; snout inflected; feet formed for walking.

The fulgora lanternaria, or Peruvian lantern-fly, is undoubtedly one of the most curious of insects. It is of a very considerable size, measuring nearly three inches and a half from the tip of the front to that of the tail, and about five inches and a half from wing's end to wing's end when expanded: the body is of a lengthened oval shape, and divided into several rings or segments; the head is nearly equal to the length of the rest of the animal, and is oval, inflated, and bent slightly upwards; the ground-colour is an elegant yellow, with a strong tinge of green in some parts, and marked with numerous bright red-brown variegations in the form of stripes and spots; the wings are very large, of a yellow colour, most elegantly varied with brown undulations and spots, and the lower pair are decorated by a very large eye-shaped spot on the middle of each, the iris or border of the spot being red, and the centre half red and half semitransparent white; the head or lantern is pale yellow, with longitudinal red stripes. This beautiful insect is a native of Surinam and many other parts of South America, and during the night diffuses so strong a phosphoric splendor from its head or lantern, that it may be employed for the purpose of a candle or torch; and it is said that three or four of the insects, tied to the top of a stick, are frequently used by travellers for that purpose. The celebrated madam Merian, in her work on the insects of Surinam, gives a very agreeable account of the surprise into which she was thrown by the first view of the flashes of light proceeding from these insects. "The Indians once brought me," says she, "before I knew that they shone by night, a number of these lantern-flies, which I shut up in a large wooden box. In the night they made such a noise that I awoke in a fright, and ordered a light to be brought, not knowing whence the noise proceeded. As we found that it came from the box, we opened it, but were still much more alarmed, and let it fall to the ground in a fright, at seeing a flame of fire come out of it; and as many animals as came out, so many flames of fire appeared. When we found this to be the case, we recovered from our fright, and again collected the insects, highly admiring their splendid appearance."

Dr. Darwin, in a note to some lines relative to luminous insects, in his beautiful poem the Loves of the Plants, makes madam Merian affirm, that she drew and finished her figure of the insect by its own light. On examination, however, we cannot find the least authority for this declaration on the part of madam Merian, who relates only what is above stated, with the observation that the light of one of the insects is sufficient to read a common newspaper by. It may be proper to add, that this celebrated lady falls into a mistake in supposing that a species of cicada, which she represents on the same plate with the lantern-fly, was its larva; and that it gradually was transformed into the fulgora. This information indeed she merely gives as the popular report, but at the same time takes the liberty of representing the insect in its supposed half-complete state, with the head of the fulgora, and the wings and body of the cicada. See Plate LX. Nat. Hist. fig. 211.

2. The fulgora candelaria is a much smaller species than the preceding, and is a native of China. It measures nearly two inches in length, and two inches and a half in breadth, with the wings expanded: the body is oval, and the head produced into a long horn-shaped process; the colours are very elegant, the head and horn being of a fine reddish brown or purple, and covered with numerous white specks of a mealy appearance; the thorax is of a deep or orange-yellow, and the body black above, but deep yellow beneath; the wings are oval, the upper pair blackish, with very numerous and close-set green reticulations, dividing the whole surface into innumerable squares or marks, and are farther decorated by several yellow bars and spots; the under wings are orange coloured, with broad black tips.

3. Fulgora diadema is an Indian species, and is distinguished by having a long, spiny, or muricated front, with a triple division at the tip; its colour is brown, with red and yellow variegations; it seems to have been first described and figured in the work of Seba: in size it is nearly similar to that of the preceding species.

FULICA, the *gallinule* and *coot*, in ornithology, a genus of birds of the order of grallæ. It has a convex bill, with the upper mandible fornicated over the lower at the edge; the lower mandible is gibbous behind the tip. The forehead is bald, and the feet have four toes, subpinnated. There are 25 species, 18 of which belong to the gallinule division, distinguished by having the toes furnished with broad scalloped membranes, and seven comprehend the coots which have the toes divided to their origin. The following species are among the most distinguished:

1. The chloropus, or common gallinule, is in length about 14 inches, and has a bald forehead and broad flat toes. It gets its food on grassy banks, and borders near fresh waters, and in the very waters if they are weedy. It builds upon low trees and shrubs by the water-side, breeding twice or thrice in a summer, and, when the young are grown up, drives them away to shift for themselves. This bird strikes with its bill like a hen, and in the spring has a shrill call. In flying, it hangs down its legs; in running, it often flirts up its tail, and shows the white feathers. We may observe, that the bottoms of its toes are so very flat and broad that it seems to be the bird which connects the cloven-footed aquatics with the next tribe, viz. fin-toed. It is pretty common on the continent, though in some parts more scarce than in others. It is also an inhabitant of America, from New York to Carolina, and is recorded as a native of Jamaica and other islands in the West Indies. It is said to feed on plants and small fish, and the flesh is for the most part pretty good. See Plate LX. Nat. Hist. fig. 213.

2. The porphyrio, or purple gallinule, is about the size of a domestic fowl, or 17 inches in length. It is more or less common in all the warmer parts of the globe. On the coasts of Barbary they abound, as well as in some of the islands of the Mediterranean. In Sicily they are bred in plenty, and kept for their beauty; but whether indigenous there, is uncertain. It is frequently met with in various parts of the south of Russia and the western parts of Siberia, among reedy places: in the neighbourhood of the Caspian Sea it is not uncommon; but in the cultivated rice grounds of Ghilar in Persia, it is in great plenty and high plumage. The female makes her nest among the reeds in the middle of March; lays three or four eggs, and sits from three to four weeks. It will feed on many things, such as fruit, roots of plants, and grain; but will

eat fish with avidity, dipping them into the water before it swallows them. It will frequently stand on one leg, and lift the food to its mouth with the other like a parrot. A pair of these kept in an aviary in France made a nest of small sticks mixed with a quantity of straw, and laid six white eggs, perfectly round; but the hen was careless of them, and they came to nothing. The flesh is said to be exquisite in flavour.

3. The atra or common coot, has a bald forehead, a black body, and lobated toes, and is about fifteen inches in length. They frequent lakes and still rivers; making their nests among the rushes, with grass, reeds, &c. floating on the water, so as to rise and fall with it. They lay five or six large eggs, of a dirty whitish hue, sprinkled over with minute deep rust-coloured spots; and it is said that sometimes they will lay 14 or more eggs. The young, when just hatched, are very deformed, and the head mixed with a red coarse down. In winter they often repair to the sea; and the channel near Southampton is sometimes observed almost covered with them. They are often brought to that market, where they are exposed to sale without their feathers, and scalded like pigs. This species is not so numerous as might be expected; for we find that vast numbers fall a prey while young to the buzzards, which frequent the marshes. Their food is small fish and water-insects; but they will sometimes eat the roots of the bulrush, and with it feed the young: they are said likewise to eat grain. This species is supposed to extend throughout the old continent, and perhaps the new also.

4. The aterrima, or greater coot, is of a larger size than the last, and its plumage is blacker. This species is said to be found in Lancashire and Scotland; but is more plentiful on the continent, being found in Russia and the western parts of Siberia very common. See Plate LX. Nat. Hist. fig. 212.

FULLER, a workman employed in the woollen manufactories to mill or scour cloths, serges, and other stuffs, in order to render them more thick, compact, and durable. See FULLING.

FULLER'S EARTH, in natural history, a species of clay, of a greyish ash-coloured brown, in all degrees from very pale to almost black, and it has generally something of a greenish cast. It is very hard and firm, of a compact texture, of a rough and somewhat dusty surface that adheres slightly to the tongue. It is very soft to the touch, not staining the hands, nor breaking easily between the fingers. It has a little harshness between the teeth, and melts freely in the mouth. Thrown into water, it makes no ebullition or hissing; but swells gradually in bulk, and falls into a fine soft powder. It makes no effervescence with nitrous acid.

A specimen from Hampshire, analysed by Bergman, contained

51.8	silica
25.0	alumina
3.3	carbonat of lime
3.7	oxyd of iron
0.7	carbonat of magnesia
15.5	moisture
100.0	

This earth is used by fullers to take grease out of their cloth before they apply soap. It is essential to fuller's earth that the particles of silica should be very fine, otherwise they would cut the cloth. Any clay possessed of this property may be considered as fuller's earth; for it is the alumina alone which acts upon the cloth, on account of its strong affinity for greasy substances.

FULLING, the art or act of cleansing, scouring, and pressing cloths, stuffs, and stockings, to render them stronger, closer, and firmer; called also milling. The fulling of cloths and other stuffs is performed by a kind of water-mill, thence called fulling or scouring-mill. These mills, except in what relates to the mill-stones and hopper, are much the same with corn-mills: and there are even some which serve indifferently for either use; corn being ground, and cloths fulled, by the motion of the same wheel. Whence in some places, particularly in France, the fullers are called millers; as grinding corn and milling stuffs at the same time.

The principal parts of the fulling-mill are: the wheel, with its trundle; which gives motion to the tree or middle, whose teeth communicate it to the pestles or stampers, which are hereby raised and made to fall alternately, according as its teeth catch on or quit a kind of latch in the middle of each pestle. The pestles and troughs are of wood; each trough having at least two, sometimes three, pestles, at the discretion of the master, or according to the force of the stream of water. In these troughs are laid the cloths, stuffs, &c. intended to be fulled: then, letting the current of water fall on the wheel, the pestles are successively let fall thereon, and by their weight and velocity stamp and press the stuffs very strongly, which by this means become thickened and condensed. In the course of the operation, they sometimes make use of urine, sometimes of fuller's earth, and sometimes of soap. To prepare the stuffs to receive the first impressions of the pestle, they are usually laid in urine; then in fuller's earth and water; and, lastly, in soap dissolved in hot water. Soap alone would do very well; but this is expensive: though fuller's earth, in the way of our dressing, is scarcely inferior to it; but then it must be well cleared of all stones and grittinesses, which are apt to make holes in the stuff. As to urine, it is certainly prejudical, and ought to be entirely discarded; not so much on account of its ill smell, as of its sharpness and saltness, which qualities are apt to render the stuffs dry and harsh.

The method of fulling cloths and woollen stuffs with soap is this: A coloured cloth, of about 45 ells, is to be laid in the usual manner in the trough of a fulling-mill, without first soaking it in water, as is commonly practised in many places. To full this trough of cloth, 15 pounds of soap are required, one-half of which is to be melted in two pails of river or spring water, made as hot as the hand can well bear it. This solution is to be poured by little and little upon the cloth, in proportion as it is laid in the trough; and thus it is to be fulled for at least two hours; after which it is to be taken out and stretched. This done, the cloth is immediately returned into the same trough, without any new soap, and there fulled two hours more. Then taking it out, they wring it well, to express all the grease and filth. After the second fulling, the remainder of the foap is dissolved as in the former, and cast four different times on the cloth, re-

membering to take out the cloth every two hours to stretch it, and undo the plaits and wrinkles it has acquired in the trough. When they perceive it sufficiently fulled, and brought to the quality and thickness required, they scour it in hot water, keeping it in the trough till it is quite clean. As to white cloths, as these full more easily and in less time than coloured ones, a third part of the soap may be spared.

The fulling of stockings, caps, &c. should be performed somewhat differently, viz. either with the feet or the hands, or a kind of wooden rack, either armed with teeth of the same matter, or else horses or bullocks teeth. The ingredients made use of are, urine, green soap, white soap, and fuller's earth. But the urine also is reckoned prejudicial here. Woven stockings, &c. should be fulled with the soap alone: for those that are knit, earth may be used with the soap. Indeed it is common to full these kinds of works with the mill, after the usual manner of cloths, &c.; but that is too coarse and violent a manner, and apt to damage the work, unless it is very strong.

Plate Foundry, &c. fig. 10. is a perspective view of a fulling-mill. A is the shaft which works it by the power of horses, water, steam, &c. This shaft has four arms or lifters BD upon it, two of which are to raise the wooden beater E, and the other two are to raise the beater F. In well executed mills, the shaft is made of cast-iron, as shown in fig. 12; and then the arms BDMN have rollers at their ends. The beaters E, F, are made of hard wood, as shown in fig. 11; G is the centre on which it turns, made of wood; H is a large block of wood wedged to the bar IK, which passes through it; it has three pieces of board *abc* pegged to it. The part K of the piece IK is shod with iron at the under side, to preserve it from being worn by the lifters. Two of these beaters work in a frame, shown open in fig. 13. OPQR is a large block of wood, hewn out as in the figure; to this are fastened the curved pieces ST, in which there is left two openings *de*, through which the parts K of the beaters, fig. 11. pass, and the centres lay in small holes *fghi:* when the beaters are in, as shown in fig. 10. the outside of the head H move as close to the curves ST as possible without touching, when they are in motion. The block is boarded up on both sides, as shown in fig. 10.; but one side is not boarded so high as the other, and has a moveable board *lm*, which fits into a groove for the convenience of putting in and taking out the cloth. The operation is as follows: The board *lm* is removed, and the cloth put in so as to lay between the heads H of the beaters, and the curve part XY, fig. 13.; the beaters are then set to work, and the lifters first take up one beater, and as soon as it lets that fall, it begins to take up the other: this motion continually shoves the cloth round in the curve from Y to X; and by its falling again when the beater is lifted into the place it before occupied, a fresh surface is continually exposed to the action of the boards *abc*, fig. 11. and to small streams of water supplied by a pipe *no*, fig. 10. which is full of holes: the quantity is regulated by a cock *p*. When the beaters are to be stopped, the workman takes a hankspike and lays it over the hook *q*, and when the beater is lifted to the highest, he shoves the end of the handspike under it, so as to prevent its falling down again; he then raises it enough to put an iron rod through the hole *r*: this operation is repeated to the other beater, and the iron is pushed farther in, so as to hold them both up. This machine is fixed down by two beams under the floor, between which the projector W of fig. 13. is bolted, and it is steadied by two struts, fig. 10.

FULMINATION, in chemistry. When three parts of nitre, two parts of potass, and one part of sulphur, all previously well dried, are mixed together in a warm mortar, the resulting compound is known by the name of *fulminating powder*.

If a little of this powder is put upon an iron spoon, and placed upon burning coals, or held above the flame of a candle, it gradually blackens, and at last melts. At that instant it explodes with a very violent report, and a strong impression is made upon the bottom of the spoon, as if it had been pressed down very violently. This sudden and violent combustion is occasioned by the rapid action of the sulphur on the nitre. By the application of the heat, the sulphur and potass form a sulphuret, which is combustible at a lower heat than even sulphur.

Sulphurated hydrogen gas, azotic gas, and perhaps sulphuric acid gas, are disengaged almost instantaneously. It is to the sudden action of these on the surrounding air that the report is to be ascribed. Its loudness depends upon the combustion of the whole powder at the same instant, which is secured by the previous fusion that it undergoes; whereas the grains of gunpowder burn in succession.

Fulminating gold. Dissolve pure gold in nitro-muriatic acid to saturation, and dilute the solution with three times its bulk of distilled water, and add to it gradually some pure ammonia, a yellow precipitate will be obtained, which must be repeatedly washed with distilled water, and dried on a chalk-stone or in a filter. When perfectly dry, it is called fulminating gold, and detonates by heat, as may be shown by heating a few grains of it on the point of a knife over the candle.

Fulminating silver. Dissolve fine silver in pale nitric acid, and precipitate the solution by lime water; decant the fluid, mix the precipitate with liquid ammonia, and stir it till it assumes a black colour; then decant the fluid, and leave it in the open air to dry. This product is fulminating silver, which when once obtained cannot be touched without producing a violent explosion. It is the most dangerous preparation known, for the contact of fire is not necessary to cause it to detonate. It explodes by the mere touch. Its preparation is so hazardous, that it ought not to be attempted without a mask, with strong glass eyes, upon the face. No more than a single grain ought at any time to be tried as an experiment. This was invented by M. Berthollet.

M. Chenevix has invented a fulminating silver not so dangerous as that just mentioned. It explodes only by a slight friction in contact with combustible bodies. It is thus prepared: Diffuse a quantity of alumina through water, and let a current of oxygenated muriatic acid gas pass through it for some time. Then digest some phosphate of silver on the solution of the oxygenated muriate of alumina, and evaporate it slowly. The product obtained will be a hyper-oxygenated muriate of silver, a single grain of which, in contact with two or three of sulphur, will explode violently with the slightest friction.

Fulminating mercury. The mercurial preparations which fulminate, when mixed with sulphur, and gradually exposed to a gentle heat, are well known to chemists: they were discovered, and have been fully described, by Mr. Bayen.

"MM. Brugnatelli and Van Mons have likewise produced fulminations by concussion, as well by nitrate of mercury and phosphorus as with phosphorus and most other nitrates. Cinnabar likewise is amongst the substances which, according to MM. Fourcroy and Vauquelin, detonate by concussion with oxymuriate of potash.

"M. Ameilon had, according to M. Berthollet, observed, that the precipitate obtained from nitrate of mercury, by oxalic acid, fuses with a hissing noise.

"But mercury, and most if not all its oxyds, may, by treatment with nitric acid and alcohol, be converted into a whitish crystallized powder, possessing all the inflammable properties of gunpowder, as well as many peculiar to itself.

"I was led to this discovery (says Mr. Howard, the inventor) by a late assertion, that hydrogen is the basis of the muriatic acid: it induced me to attempt to combine different substances with hydrogen and oxygen. With this view I mixed such substances with alcohol and nitric acid as might (by predisposing affinity) favour as well as attract an acid combination of the hydrogen of the one, and the oxygen of the other. The pure red oxyd of mercury appeared not unfit for this purpose; it was therefore intermixed with alcohol, and upon both nitric acid was affused. The acid did not act upon the alcohol so immediately as when these fluids are alone mixed together, but first gradually dissolved the oxide: however, after some minutes had elapsed, a smell of ether was perceptible, and a white dense smoke, much resembling that from the liquor fumans of Libavius, was emitted with ebullition. The mixture then threw down a dark-coloured precipitate, which by degrees became nearly white. This precipitate I separated by filtration; and observing it to be crystallized in smaller acicular crystals, of a saline taste, and also finding a part of the mercury volatilized in the white fumes, I must acknowledge I was not altogether without hopes that muriatic acid had been formed, and united to the mercurial oxide; I therefore, for obvious reasons, poured sulphuric acid upon the dried cystalline mass, when a violent effervescence ensued, and, to my great astonishment, an explosion took place. The singularity of this explosion induced me to repeat the process several times, and finding that I always obtained the same kind of powder, I prepared a quantity of it, and was led to make the series of experiments which I shall have the honour to relate in this paper.

"I first attempted to make the mercurial powder fulminate by concussion; and for that purpose laid about a grain of it upon a cold anvil, and struck it with a hammer, likewise cold. It detonated slightly, not being, as I suppose, struck with a flat blow; for upon using three or four grains, a very stunning disagreeable noise was produced, and the faces both of the hammer and the anvil were much indented.

"Half a grain, or a grain, if quite dry, is as much as ought to be used on such an occasion.

"The shock of an electrical battery, sent through five or six grains of the powder, produces a very similar effect. It seems, indeed, that a strong electrical shock generally acts on fulminating substances like the blow of a hammer. MM. Fourcroy and Vauquelin found this to be the case with all their mixtures of oxymuriate of potass.

"To ascertain at what temperature the mercurial powder explodes, two or three grains of it were floated on oil, in a capsule of leaf tin; the bulb of a Fahrenheit's thermometer was made just to touch the surface of the oil, which was then gradually heated till the powder exploded, as the mercury of the thermometer reached the 368th degree.

"Desirous of comparing the strength of the mercurial compound with that of gunpowder, I made the following experiment in the presence of my friend Mr. Abernethy.

"Finding that the powder could be fired by flint and steel, without a disagreeable noise, a common gunpowder proof, capable of containing eleven grains of fine gunpowder, was filled with it, and fired in the usual way: the report was sharp, but not loud. The person who held the instrument in his hand felt no recoil; but the explosion laid open the upper part of the barrel, nearly from the touch-hole to the muzzle, and struck off the hand of the register, the surface of which was evenly indented, to the depth of 0.1 of an inch, as if it had received the impression of a punch.

"The instrument used in this experiment being familiarly known, it is therefore scarcely necessary to describe it: suffice it to say, that it was of brass, mounted with a spring register, the moveable hand of which closed up the muzzle, to receive and graduate the violence of the explosion. The barrel was half an inch in caliber, and nearly half an inch thick, except where a spring of the lock impaired half its thickness.

"A gun belonging to Mr. Keir, an ingenious artist of Camden-Town, was next charged with 17 grains of the mercurial powder, and a leaden bullet. A block of wood was placed at about eight yards from the muzzle to receive the ball, and the gun was fired by a fuse. No recoil seemed to have taken place, as the barrel was not moved from its position, although it was in no ways confined. The report was feeble: the bullet, Mr. Keir conceived, from the impression made upon the wood, had been projected with about half the force it would have been by an ordinary charge, or 68 grains, of the best gunpowder. We therefore re-charged the gun with 34 grains of the mercurial powder; and as the great strength of the piece removed any apprehension of danger, Mr. Keir fired it from his shoulder, aiming at the same block of wood. The report was like the first, sharp, but not louder than might have been expected from a charge of gunpowder. Fortunately Mr. Keir was not hurt; but the gun was burst in an extraordinary manner. The breech was what is called a patent one, of the best forged iron, consisting of a chamber 0.4 of an inch thick all round, and 0.4 of an inch in caliber; it was torn open and flawed in many directions, and the gold touch-hole driven out. The barrel into which the breach was screwed was 0.5 of an inch thick; it was split by a single crack three inches long, but this did not appear to

me to be the immediate effect of the explosion. I think the screw of the breech, being suddenly enlarged, acted as a wedge upon the barrel. The ball missed the block of wood, and struck against a wall, which had already been the receptacle of so many bullets, that we could not satisfy ourselves about the impression made by the last.

"As it was pretty plain that no gun could confine a quantity of the mercurial powder sufficient to project a bullet with a greater force than an ordinary charge of gunpowder, I determined to try its comparative strength in another way. I procured two blocks of wood, very nearly of the same size and strength, and bored them with the same instrument to the same depth. The one was charged with half an ounce of the best Dartford gunpowder, and the other with half an ounce of the mercurial powder; both were alike buried in sand, and fired by a train communicating with the powders by a small touch-hole. The block containing the gunpowder was simply split into three pieces: that charged with the mercurial powder was burst in every direction, and the parts immediately contiguous to the powder were absolutely pounded, yet the whole hung together, whereas the block split by the gunpowder had its parts fairly separated. The sand surrounding the gunpowder was undoubtedly most disturbed: in short, the mercurial powder appeared to have acted with the greatest energy, but only within certain limits.

"The effects of the mercurial powder, in the last experiments, made me believe that it might be confined, during its explosion, in the centre of a hollow glass globe. Having therefore provided such a vessel, seven inches in diameter, and nearly half an inch thick, mounted with brass caps, and a stop-cock, I placed ten grains of mercurial powder on thin paper, laid on iron wire, 149th of an inch thick, across the paper, through the midst of the powder, and, closing the paper, tied it fast at both extremities with silk to the wire. As the enclosed powder was now attached to the middle of the wire, each end of which was connected with the brass caps, the packet of powder became, by this disposition, fixed in the centre of the globe. Such a charge of the electrical battery was then sent along the wire, as a preliminary experiment (with Mr. Cuthbertson's electrometer) had shown me would, by making the wire red hot, inflame the powder. The glass globe withstood the explosion, and of course retained whatever gases were generated; its interior was thinly coated with the quicksilver, in a very divided state. A bent glass tube was now screwed to the stop-cock of the brass cap, which being introduced under a glass jar standing in the mercurial bath, the stop-cock was opened. Three cubical inches of air rushed out, and a fourth was set at liberty when the apparatus was removed to the water tub. The explosion being repeated, and the air all received over water, the quantity did not vary. To avoid an error from change of temperature, the glass globe was, both before and after the explosion, immersed in water of the same temperature. It appears, therefore, that the ten grains of powder produced four cubical inches only of air.

"To continue the comparison between the mercurial powder and gunpowder, 10 grains of the best Dartford gunpowder were in a similar manner set fire to in the glass globe: it remained entire. The whole of the powder did not explode, for some complete grains were to be observed adhering to the interior surface of the glass. Little need be said of the nature of the gases generated during the combustion of the gunpowder: they must have been carbonic acid gas, sulphureous acid gas, nitrogen gas, and (according to Lavoisier) perhaps hydrogen gas. As to the quantity of these, it is obvious that it could not be ascertained; because the two first were, at least in part, speedily absorbed by the alkali of the nitre, left pure after the decomposition of its nitric acid."

The following description will give the experimental philosopher a clear idea of the instrument used in this business.

The ball or globe of glass is nearly half an inch thick, and seven inches in diameter. It has two necks, on which are cemented two brass caps, each being perforated with a female screw, to receive the male ones; through the former a small hole is drilled; the latter is furnished with a perforated stud or shank. By means of a leather collar the neck can be air-tightly closed. When a portion of the powder is to be exploded, it must be placed on a piece of paper, and a small wire laid across the paper, through the midst of the powder: the paper being then closed, it is to be tied at each end to the wire with a silken thread. One end of this wire is to be fastened to the end of the shank, and the screw inserted to half its length into the brass cap; the other end of the wire, by means of a needle, is to be drawn through the hole. The screw being now fixed in its place, and the wire drawn tight, is to be secured by pushing the irregular wooden plug into the aperture of the screw, taking care to leave a passage for the air. The stop-cock is now to be screwed on. The glass tube is bent, that it may more conveniently be introduced under the receiver of a pneumatic apparatus.

"From some of the experiments in which the gunpowder proof and the gun were burst, it might be inferred, that the astonishing force of the mercurial powder is to be attributed to the rapidity of its combustion; and a train of several inches in length being consumed in a single flash, it is evident that its combustion must be rapid. But from other experiments it is plain that this force is restrained to a narrow limit, both because the block of wood charged with the mercurial powder was more shattered than that charged with the gunpowder, whilst the sand surrounding it was least disturbed, and likewise because the glass globe withstood the explosion of ten grains of powder fixed in its centre; a charge I have twice found sufficient to destroy old pistol barrels, which were not injured by being fired when full of the best gunpowder. It also appears from the last experiment, that 10 grains of the powder produced by ignition four cubical inches only of air; and it is not to be supposed that the generation, however rapid, of four cubical inches of air, will alone account for the described force; neither can it be accounted for by the formation of a little water, which, as will hereafter be shown, happens at the same moment; the quantity formed from ten grains must be so trifling, that I cannot ascribe much force to the expansion of its vapour. The sudden vaporation of a part of the mercury seems to me a principal cause of this immense yet limited force; because its limitation may then be explained, as it is well known that

mercury easily parts with caloric, and requires a temperature of 600 degrees of Fahrenheit, to be maintained in the vaporous state. That the mercury is really converted into vapour, by ignition of the powder, may be inferred from the thin coat of divided quicksilver, which, after the explosion in the glass globe, covered its interior surface; and likewise from the quicksilver with which a tallow candle, or a piece of gold, may be evenly coated, by being held at a small distance from the inflamed powder. These facts certainly render it more than probable, although they do not demonstrate that the mercury is volatilized; because it is not unlikely that many mercurial particles are mechanically impelled against the surface of the glass, the gold, and the tallow.

"As to the force of the dilated mercury, Mr. Baumé relates a remarkable instance of it, as follows:

'Un alchymiste se présenta à Mr. Geoffroy, et l'assura qu'il avoit trouvé le moyen de fixer le mercure par une opération fort simple. Il fit construire six boites rondes en fer fort épais, qui entroient les unes dans les autres: la dernière étoit assujettie par deux cercles de fer qui se croisoient en angles droits. On avoit mis quelques livres de mercure dans la capacité de la première: on mit cet appareil dans un fourneau assez rempli de charbon pour faire rougir à blanc les boites de fer; mais, lorsque la chaleur eut pénétré suffisamment le mercure, les boites crevèrent, avec une telle explosion qu'il se fit un bruit épouvantable: des morceaux de boites furent lancés avec tant de rapidité qu'il y en eut qui passèrent au travers de deux planchers; d'autres firent sur la muraille des effects semblables a ceux des éclats de bombes.'—Chymie Expérimental et Raisonnée tom. ii. p. 393.

"Had the alchemist proposed to fix water by the same apparatus, the nest of boxes must, I suppose, have likewise been ruptured; yet it does not follow that the explosion would have been so tremendous: indeed, it is probable that it would not, for if (as Mr. Kirwan remarked to me) substances which have the greatest specific gravity have likewise the greatest attraction of cohesion, the supposition that the vapour of water, would agree with a position of sir Isaac Newton, that those particles recede from one another with the greatest force, and are most difficultly brought together, which upon contact cohere most strongly.

"Before I attempt to investigate the constituent principles of this powder, it will be proper to describe the process and manipulations which, from frequent trials, seem to be best calculated to produce it. 100 grains, or a greater proportional quantity of quicksilver, (not exceeding 500 grains), are to be dissolved, with heat, in a measured ounce and a half of nitric acid. This solution being poured cold upon two measured ounces of alcohol, previously introduced into any convenient glass vessel, a moderate heat is to be applied until an effervescence is excited. A white fume then begins to undulate on the surface of the liquor; and the powder will be gradually precipitated, upon the cessation of action and re-action. The precipitate is to be immediately collected on a filter, well washed with distilled water, and carefully dried in a heat not much exceeding that of a water bath. The immediate edulcoration of the powder is material, because it is liable to the re-action of nitric acid; and, whilst any of that acid adheres to it, it is very subject to the influence of light. Let it also be cautiously remembered, that the mercurial solution is to be poured upon the alcohol.

"I have recommended quicksilver to be used in preference to an oxide, because it seems to answer equally, and is less expensive; otherwise, not only the pure red oxide, but the red nitrous oxide, and turpeth, may be substituted; neither does it seem essential to attend to the precise specific gravity of the acid, or the alcohol. The rectified spirit of wine, and the nitrous acid of commerce, never failed, with me, to produce a fulminating mercury. It is indeed true, that the powder prepared without attention is produced in different quantities, varieties in colour, and probably in strength. From analogy, I am disposed to think the whitest is the strongest; for it is well known that the black precipitates of mercury approach the nearest to the metallic state. The variation in quantity is remarkable; the smallest quantity I ever obtained from 100 grains of quicksilver being 120 grains, and the largest 132 grains. Much depends on very minute circumstances. The greatest product seems to be obtained when a vessel is used which condenses and causes most ether to return into the mother liquor; besides which, care is to be had in applying the requisite heat, that a speedy and not a violent action be effected. 100 grains of an oxide are not so productive as 100 grains of quicksilver.

"As to the colour, it seems to incline to black when the action of the acid of the alcohol is most violent, and vice versa.

"I need not observe, that the gases which were generated during the combustion of the powder in the glass globe, were necessarily mixed with atmospheric air; the facility with which the electric fluid passes through a vacuum, made such a mixture unavoidable.

"The cubical inch of gas received over water was not readily absorbed by it; and, as it soon extinguished a taper without becoming red, or being itself inflamed, barytes water was let up to the three cubical inches received over mercury, when a carbonate of barytes was immediately precipitated.

"The residue of several explosions, after the carbonic acid had been separated, was found, by the test of nitrous gas, to contain nitrogen or azotic gas; which does not proceed from any decomposition of atmospheric air, because the powder may be made to explode under the exhausted receiver of an air-pump. It is therefore manifest that the gases generated during the cobustion of the fulminating mercury, consist of carbonic acid and nitrogen gases.

"The principal re-agents which decompose the mercurial powder are the nitric, the sulphuric, and the muriatic acids. The nitric changes the whole into nitrous gas, carbonic acid gas, acetous acid, and nitrate of mercury. I resolved it into these different principles, by distilling it pneumatically with nitric acid: this acid, upon the application of heat, soon dissolved the powder, and extricated a quantity of gas, which was found, by well-known tests, to be nitrous gas mixed with carbonic acid gas. The distillation was carried on until gas no longer came over. The liquor of the retort was then mixed with the liquor collected in the receiver, and the whole saturated with potass; which precipitated the mercury in a yellowish brown powder, nearly as it would

have done from a solution of nitrate of mercury. This precipitate was separated by a filter, and the filtrated liquor evaporated to a dry salt, which was washed with alcohol. A portion of the salt being refused by this menstruum, it was separated by filtration, and recognized, by all its properties, to be nitrate of potass. The alcoholic liquor was likewise evaporated to a dry salt, which, upon the effusion of a little concentrate sulphuric acid, emitted acetous acid, contaminated with a feeble smell of nitrous acid, owing to the solubility of a small portion of the nitre in the alcohol.

"The sulphuric acid acts upon the powder in a remarkable manner, as has already been noticed. A very concentrate acid produces an explosion nearly at the instant of contact, on account, I presume, of the sudden and copious disengagement of caloric from a portion of powder which is decomposed by the acid. An acid somewhat less concentrate likewise extricates a considerable quantity of caloric, with a good deal of gas; but, as it effects a complete decomposition, it causes no explosion. An acid diluted with an equal quantity of water, by the aid of a little heat, separates the gas so much less rapidly, that it may with safety be collected in a pneumatic apparatus. But, whatever be the density of the acid (provided no explosion be produced), there remains in the sulphuric liquor, after the separation of the gas, a white inflammable and uncrystallized powder mixed with some minute globules of quicksilver.

"To estimate the quantity, and observe the nature, of this uninflammable substance, I treated 100 grains of the fulminating mercury with sulphuric acid a little diluted. The gas being separated, I decanted off the liquor as it became clear, and freed the insoluble powder from acid by edulcoration with distilled water; after which I dried it, and found it weighed only 84 grains; consequently had lost 16 grains of its original weight. Suspecting, from the operation of the nitric acid in the former experiment, that these 84 grains (with the exception of the quicksilver globules) were oxalate of mercury, I digested them in nitrate of lime, and found my suspicion just. The mercury of the oxalate united to the nitric acid, and the oxalic acid to the lime. A new insoluble compound was formed; it weighed, when washed and dry, 48.5 grains. Carbonate of potass separated the lime, and formed oxalate of potass, capable of precipitating lime-water and muriate of lime; although it had been depurated from excess of alkali, and from carbonate acid, by a previous addition of acetous acid. That the mercury of the oxalate in the 84 grains had united to the nitric acid of the nitrate of lime was proved, by dropping muriatic acid into liquor from which the substance demonstrated to be oxalate of lime had separated; for a copious precipitation of calomel instantly ensued.

"The sulphuric liquor, decanted from the oxalate of mercury, was now added to that with which it was edulcorated, and the whole saturated with carbonate of potass. As effervescence ceased, a cloudiness and precipitation followed; and the precipitate being collected, washed and dried, weighed 3.4 grains: it appeared to be a carbonate of mercury. Upon evaporating a portion of the saturated sulphuric liquor, I found nothing but sulphate of potass; nor had it any metallic taste. There then remains, without allowing for the weight of the carbonic acid united to the 3.4 grains, a deficit from the 100 grains of mercurial powder of 12.6 grains, which I ascribe to the gas separated by the action of the sulphuric acid. To ascertain the quantity, and examine the nature of the gas so separated, I introduced into a very small tubulated retort 50 grains of the mercurial powder, and poured upon it three drachms, by measure, of sulphuric acid, with the assistance of a gentle heat. I first received it over quicksilver; the surface of which, during the operation, partially covered itself with a little black powder.

"The gas, by different trials, amounted to from 28 to 31 cubical inches: it first appeared to be nothing but carbonic acid, as it precipitated barytes water, and extinguished a taper, without being itself inflamed, or becoming red. But upon letting up to it liquid caustic ammonia, there was a residue of from 5 to 7 inches of a peculiar inflammable gas, which burnt with a greenish-blue flame. When I made use of the water-tub, I obtained from the same materials, from 25 to 27 inches only of gas, although the average quantity of the peculiar inflammable gas was likewise from 5 to 7 inches: therefore, the difference of the aggregate product, over the two fluids, must have arisen from the absorption, by the water, of a part of the carbonic acid in its nascent state. The variation of the quantity of the inflammable gas, when powder from the same parcel is used, seems to depend upon the acid being a little more or less dilute.

"With respect to the nature of the peculiar inflammable gas, it is plain to me, from the reasons I shall immediately adduce, that it is no other than the gas (in a pure state) into which the nitrous etherized gas can be resolved, by treatment with dilute sulphuric acid.

"The Dutch chemists have shown, that the nitrous etherized gas can be resolved into nitrous gas, by exposure to concentrate sulphuric acid, and that, by using a dilute instead of a concentrate acid, a gas is obtained which enlarges the flame of a burning taper, so much like the gaseous oxide of azote, that they mistook it for that substance, until they discovered that it was permanent over water, refused to detonate with hydrogen, and that the fallacious appearance was owing to a mixture of nitrous gas with inflammable gas.

"The inflammable gas separated from the powder, answers to the description of the gas which at first deceived the Dutch chemists: 1st, in being permanent over water; 2dly, refusing to detonate with hydrogen; and, 3dly, having the appearance of the gaseous oxide of azote, when mixed with nitrous gas.

"The gas separable by the same acid, from nitrous etherized gas, and from the mercurial powder, have therefore the same properties. Every chemist would thence conclude, that the nitrous etherized gas is a constituent part of the powder, and the inflammable and nitrous gas, instead of the inflammable and carbonic acid gas, had been the mixed product extricated from it by dilute sulphuric acid.

"It however appears to me, that nitrous gas was really produced by the action of the dilute sulphuric acid; and that, when produced, it united to an excess of oxygen present in the oxalate of mercury.

"To explain how this change might happen, I must premise, that my experiments have shown me that oxalate of mercury can exist in two, if not in three states.

1st. By the discovery of Mr. Ameilon, the precipitate obtained by oxalic acid, from nitrate of mercury, fuses with a hissing noise. The precipitate is an oxalate of mercury, seemingly with excess of oxygen. Mercury dissolved in sulphuric acid and precipitated by oxalic acid, and also the pure red oxide of mercury digested with oxalic acid, give oxalates in the same state. 2dly. Acetate of mercury, precipitated by oxalic acid, although a true oxalate is formed, has no kind of inflammability. I consider it as an oxalate with less oxygen than those above-mentioned. 3dly. A solution of nitrate of mercury, boiled with dulcified spirit of nitre, gives an oxalate more inflammable than any other; perhaps it contains most oxygen.

"The oxalate of mercury remaining from the powder in the sulphuric liquor is not only always in the same state as that precipitated from acetate of mercury, entirely devoid of inflammability, but contains globules of quicksilver, consequently it must have parted with even more than its excess of oxygen; and if nitrous gas was present, it would of course seize at least a portion of that oxygen. It is true, that globules of quicksilver may seem incompatible with nitrous acid; but the quantity of the one may not correspond with that of the other, or the dilution of the acid may destroy its action.

"As to the presence of the carbonic acid, it must have arisen either from a complete decomposition of a part of the oxalate; or admitting the nitrous etherized gas to be a constituent principle of the powder, from a portion of the oxygen, not taken up by the nitrous gas, being united with the carbon of the etherized gas.

"The muriatic acid, digested with the mercurial powder, dissolves a portion of it, without extricating any notable quantity of gas. The dissolution evaporated to a dry salt tastes like the corrosive sublimate; and the portion which the acid does not take up, is left in a state of an uninflammable oxalate.

"These effects all tend to establish the existence of the nitrous etherized gas, as a constituent part of the powder; and likewise corroborate the explanation I have ventured to give of the action of the sulphuric acid. Moreover, a measured ounce and a half of nitrous acid, holding 100 grains of mercury in solution and two measured ounces of alcohol, yield 90 cubical inches only of gas: whereas, without the intervention of mercury, they yield 210 inches. Upon the whole, I trust it will be thought reasonable to conclude, that the mercurial powder is composed of the nitrous etherized gas, and of oxalate of mercury with excess of oxygen. 1st. Because the nitric acid converts the mercurial powder entirely into nitrous gas, carbonic acid gas, acetous acid, and nitrate of mercury. 2dly. Because the dilute sulphuric acid resolves it into an uninflammable oxalate of mercury, and separates from it a gas resembling that into which the same acid resolves the nitrous etherized gas. 3dly. Because an uninflammable oxalate is likewise left, after the muriatic acid has converted a part of it into sublimate. 4thly. Because it cannot be formed by boiling nitrate of mercury in dulcified spirits of nitre; although a very inflammable oxalate is by this means produced. 5thly. Because the difference of the product of gas, from the same measures of alcohol and nitrous acid, with and without mercury in solution, is not trifling; and, 6thly. Because nitrogen gas was generated during its combustion in the glass globe.

"Should my conclusion be thought warranted by the reasons I have adduced, the theory of the combustion of the mercurial powder will be obvious to every chemist. The hydrogen of the oxalic acid, and of the etherized gas, is first united to the oxygen of the oxalate, forming water; the carbon is saturated with oxygen, forming carbonic acid gas; and a part, if not the whole of the nitrogen of the etherized gas, is separated in the state of nitrogen gas; both which last gases, it may be recollected, were after the explosion present in the glass globe. The mercury is revived, and, I presume, thrown into vapour; as may well be imagined, from the immense quantity of caloric extricated, by adding concentrate sulphuric acid to the mercurial powder.

"I will not venture to state with accuracy in what proportions its constituent principles are combined. The affinities I have brought into play are complicated, and the constitution of the substances I have to deal with not fully known. But to make round numbers, I will resume the statement, that 100 grains of the mercurial powder lost 16 grains of its original weight, by treatment with dilute sulphuric acid: 84 grains of the mercurial oxalate, mixed with a few minute globules of quicksilver, remained undissolved in the acid. The sulphuric liquor was saturated with carbonic of potass, and yielded 3.4 grains of carbonate of mercury. If 1.4 grains should be thought a proper allowance for the weight of carbonic acid in the 3.4 grains, I will make that deduction, and add the remaining 2 grains to the 84 grains of mercurial oxalate and quicksilver; I shall then have,

Of oxalate and mercury	86 grains.
And a deficit, to be ascribed to the nitrous etherized gas and excess of oxygen,	14
	100

"It may perhaps be proper to proceed still further, and recur to the 48.5 grains, separated by nitrate of lime from the 84 grains of mercurial oxalate and globules of quicksilver. These 48.5 grains were proved to be oxalate of lime; but they contained a minute inseparable quantity of mercury, almost in the state of quicksilver, formerly part of the 84 grains from which they were separated. Had the 48.5 grains been pure calcareous oxalate, the quantity of pure oxalic acid in them would, according to Bergmann, be 23.28 grains. Hence, by omitting the 2 grains of mercury, in the 3.4 grains of carbonate, 100 grains of the mercurial powder might have been said to contain of pure oxalic acid 23.28 grains; of mercury 62.72 grains; and of nitrous etherized gas and excess of oxygen 14 grains. But as the 48.5 grains were not pure oxalate, inasmuch as they contained the mercury they received from the 84 grains, from which they were generated by the nitrate of lime, some allowance must be made for the mercury successively intermixed with the 84 grains and the 48.5 grains. In order to make corresponding numbers, and allow for unavoidable errors, I shall estimate the quantity of that mercury to have amounted to 2 grains, which I must of course deduct from the 33.28 grains of oxalic acid. I shall then have the following statement:

That 100 grains of fulminating mercury ought to contain of pure oxalic acid,	21.28 grains.
Of mercury formerly united to the oxalic acid	60.72
Of mercury dissolved in the sulphuric liquor,	2
And of mercury left in the sulphuric liquor after the separation of the gases,	2
Total of mercury,	64.72
Of nitrous etherized gas, and excess of oxygen,	14
	100

"Since 100 grains of the powder seem to contain 64.72 grains of mercury, it will be immediately inquired, what becomes of 100 grains of quicksilver, when treated as directed, in the description of the process for preparing the fulminating mercury.

"It has been stated that 100 grains of quicksilver produce, under different circumstances, from 120 to 132 grains of mercurial powder; and, if 100 grains of this powder contain 64.72 grains, 120 grains, or 132 grains, must, by parity of reasoning, contain 78.06 grains, or 85.47 grains; therefore 13.34 grains, or 20.75 grains, more of the 100 grains are immediately accounted for; because 64.72 grains + 13.34 grains = 78.06, and 64.72 grains + 20.75 grains = 85.47 grains. The remaining deficiency of 21.94 grains, or 14.53 grains, which with the 78.06 grains, or 85.47 grains, would complete the original 100 of quicksilver, remains partly in the liquor from which the powder is separated, and is partly volatilized in the white dense fumes, which in the beginning of this paper I compared to the liquor fumans of Libavius. The mercury cannot, in either instance, be obtained in a form immediately indicative of its quantity; and a series of experiments, to ascertain the quantities in which many different substances can combine with mercury, is not my present object. After observing that the mercury left in the residuary liquor can be precipitated in a very subtile dark powder, by carbonate of potass, I shall content myself with examining the nature of the white fumes.

"It is clear that these white fumes contain mercury: they may be wholly condensed in a range of Woulfe's apparatus, charged with a solution of muriate of ammonia. When the operation is over, a white powder is seen floating with ether on the saline liquor, which, if the bottles are agitated, is entirely dissolved. After the mixture has been boiled, or for some time exposed to the atmosphere, it yields to caustic ammonia a precipitate, in all respects similar to that which is separated by caustic ammonia from corrosive sublimate.

"I would infer from these facts, that the white dense fumes consist of mercury, or perhaps oxide of mercury, united to the nitrous etherized gas; and that, when the muriate of ammonia containing them is exposed to the atmosphere, or is boiled, the gas separates from the mercury; and the excess of nitrous acid, which always comes over with nitrous ether, decomposes the ammoniacal muriate of sublimate, and forms corrosive mercurial muriate or sublimate. This theory is corroborated by comparing the quantity of gas estimated to be contained in the fulminating mercury with the quantities of gas yielded from alcohol and nitrous acid, with and without mercury in solution; not to mention that more ether, as well as more gas, is produced without the intervention of mercury; and that, according to the Dutch chemists, the product of ether is always in the inverse ratio to the product of nitrous etherized gas. Should a further proof be thought necessary to the existence of the nitrous etherized gas in the fulminating mercury, as well as in the white dense fumes, it may be added, that if a mixture of alcohol and nitrous acid holding mercury in solution be so dilute, and exposed of a temperature so low, that neither ether nor nitrous etherized gas are produced, the fulminating mercury, or the white fumes, will never be generated; for, under such circumstances, the mercury is precipitated chiefly in the state of an inflammable oxalate. Further, when we consider the different substances formed by an union of nitrous acid and alcohol, we are so far acquainted with all, except the ether and the nitrous etherized gas, as to create a presumption, that no others are capable of volatilizing mercury, at the very low temperature in which the white fumes exist, since during some minutes, they are permanent over water of 40° Fahrenheit.

"Hitherto, as much only has been said of the gas which is separated from the mercurial powder by dilute sulphuric acid, as was necessary to identify it with that into which the same acid can resolve the nitrous etherized gas: I have further to speak of its peculiarity.

"The characteristic properties of the inflammable gas seem to me to be the following: 1st. It does not diminish in volume, either with oxygen or nitrous gas. 2dly. It will not explode with oxygen by the electric shock, in a close vessel. 3dly. It burns like hydrocarbonate, but with a blueish-green flame; and, 4thly. It is permanent over water.

"It is of course either not formed, or is convertible into nitrous gas by the concentrate nitric and muriatic acids; because by those acids, no inflammable gas was extricated from the powder.

"Should this inflammable gas prove not to be hydrocarbonate, I shall be disposed to conclude that it has nitrogen for its basis; indeed, I am at this moment inclined to that opinion, because I find that Dr. Priestley, during his experiments on his dephlogistigated nitrous air, once produced a gas which seems to have resembled this inflammable gas, both in the mode of burning and in the colour of the flame.

"After the termination of the common solution of iron in spirit of nitre, he used heat, and got, says he, 'such a kind of air as I had brought nitrous air to be, by exposing it to iron, or liver of sulphur; for, on the first trial, a candle burned in it with a much enlarged flame. At another time, the application of a candle to air produced in the same manner, was attended with a real, though not a loud explosion; and immediately after this a greenish-coloured flame descended from the top to the bottom of the vessel in which the air was contained. In the next produce of air, from the same process, the flame descended blue, and very rapidly from the top to the bottom of the vessel.

"These greenish and blue-coloured flames, descending from the top to the bottom of the vessel, are precisely descriptive of the inflammable gas separated from the powder. If it can be produced with certainty by the

repetition of Dr. Priestley's experiments, or should it by any means be got pure from the nitrous etherized gas, my curiosity will excite me to make it the object of future research; otherwise, I must confess, I shall feel more disposed to prosecute other chemical subjects: for having reason to think that the density of the acid made a variation in the product of this gas, and having never found that any acid, however dense, produced an immediate explosion, I once poured 6 drachms of concentrate acid upon 50 grains of the powder. An explosion, nearly at the instant of contact, was effected: I was wounded severely, and most of my apparatus destroyed. A quantity moreover of the gas I had previously prepared, was lost by the inadvertency of a person who went into my laboratory, whilst I was confined by the consequences of this discouraging accident. But should any one be desirous of giving the gas a further examination, I again repeat, that as far as I am enabled to judge, it may with safety be prepared by pouring 3 drachms of sulphuric acid, diluted with the same quantity of water upon 50 grains of the powder, and then applying the flame of a candle until gas begins to be extricated. The only attempt I have made to decompose it, was by exposing it to copper and ammonia; which during several weeks did not effect the least alteration.

"I will now conclude (says Mr. Howard), by observing, that the fulminating mercury seems to be characterised by the following properties:

"It takes fire at the temperature of 368 Fahrenheit; explodes by friction, by flint and steel, and by being thrown into concentrate sulphuric acid. It is equally inflammable under the exhausted receiver of an air-pump, as surrounded by atmospheric air; and it detonates loudly, both by the blow of a hammer, and by a strong electrical shock.

"Notwithstanding the compositions of fulminating silver and of fulminating gold differ essentially from that of fulminating mercury, all three have similar qualities. In tremendous effects, silver undoutedly stands first, and gold perhaps the last. The effects of the mercurial powder and of gunpowder admit of little comparison. The one exerts, within certain limits, an almost inconceivable force: its agents seem to be gas and caloric, very suddenly set at liberty, and both mercury and water thrown into vapour. The other displays a more extended but inferior power: gas and caloric are, comparatively speaking, liberated by degrees; and water, according to count Rumford, is thrown into vapour.

"Hence it seems that the fulminating mercury, from the limitation of its sphere of action, can seldom, if ever, be applied to mining; and, from the immensity of its initial force, cannot be used in fire-arms, unless in cases where it becomes an object to destroy them; and where it is the practice to spike cannon, it may be of service, because I apprehend it may be used in such a manner as to burst cannon without dispersing any splinters.

"The inflammation of fulminating mercury by concussion offers nothing more novel or remarkable than the inflammation, by concussion, of many other substances. The theory of such inflammations has been long since exposed by the celebrated Mr. Berthollet, and confirmed by Messieurs Fourcroy, and Vanquelin: yet, I must confess, I am at a loss to understand why a small quantity of mercurial powder made to detonate by the hammer, or the electric shock, should produce a report so much louder than when it is inflamed by a match, or by flint and steel. It might at first be imagined, that the loudness of the report could be accounted for, by supposing the instant of the inflammation, and that of the powder's confinement between the hammer and anvil, to be precisely the same, but, when the electrical shock is sent though or over a few grains of the powder, merely laid on ivory, and a loud report in consequence, I can form no idea of what causes such a report.

"The operation by which the powder is prepared, is perhaps one of the most beautiful and surprising in chemistry; and it is not a little interesting to consider the affinities which are brought into play. The superabundant nitrous acid of the mercurial solution must first act on the alcohol, and generate ether, nitrous etherized gas, and oxalic acid. The mercury unites to the two last in their nascent state, and relinquishes fresh nitrous acid, to act upon any unaltered alcohol. The oxalic acid, a predisposing affinity seems exerted in favour of its quantity, is evidently not formed fast enough to retain all the mercury; otherwise, no white fumes during a considerable period of the operation, but fulminating mercury alone will be produced.

"Should any doubt still be entertained of the existence of the affinities which have been called predisposing or conspiring, a proof that such affinities really exist, will, I think, be afforded, by comparing the quantity of oxalic acid which can be generated from given measures of nitrous acid and alcohol, with the intervention of mercury, and the intervention of other metals. For instance, when two measured ounces of alcohol are treated with a solution of 100 grains of nickel in a measured ounce and a half of nitrous acid, little or no precipitate is produced; yet, by the addition of oxalic acid to the residuary liquor, a quantity of oxalate of nickel, after some repose, is deposited. Copper affords another illustration; 100 grains of copper dissolved in a measured ounce and a half of nitrous acid, and treated with alcohol, yielded me about 18 grains of oxalate, although cupreous oxalate was plentifully generated by dropping oxalic acid into the residuary liquor. About 21 grains of pure oxalic acid seem to be produced from the same materials, when 100 grains of mercury are interposed. Besides, according to the Dutch paper, more than once referred to, acetous acid is the principal residue after the preparation of nitrous ether. How can we explain the formation of a greater quantity of oxalic acid from the same materials, with the intervention of 100 grains of mercury, than with the intervention of 100 grains of copper, otherwise than by the notion of conspiring affinities, so analogous to what we see in other phenomena of nature?

"I have attempted, without success, to communicate fulminating properties, by means of alcohol, to gold, platina, antimony, tin, copper, iron, lead, zinc, nickel, bismuth, cobalt, arsenic, and manganese; but I have not yet sufficiently varied my experiments to enable me to speak with absolute certainty. Silver, when 20 grains of it were treated with nearly the same proportions of nitrous acid, and alcohol as 100 grains of mercury, yielded, at the end of the operation, about three grains of a grey precipitate, which fulminated with extreme

violence. Mr. Cruickshank had the goodness to repeat the experiment: he dissolved 40 grains of silver in two ounces of the strongest nitrous acid diluted with an equal quantity of water, and obtained (by means of two ounces of alcohol) 60 grains of a very white powder, which fulminated like the grey precipitate above described. It probably combines with the same principles as the mercury, and of course differs from Mr. Berthollet's fulminating silver, before alluded to. I observe, that a white precipitate is always produced in the first instance; and that it may be preserved by adding water as soon as it is formed; otherwise, when the mother liquor is abundant, it often becomes grey, and is re-dissolved."

Several trials of the mercurial powder were afterwards made at Woolwich, in conjunction with colonel Bloomfield and Mr. Cruickshank, upon heavy guns, carronades, &c. from which Mr. Howard generally infers, that any piece of ordinance might be destroyed, by employing a quantity of the mercurial powder equal in weight to one half of the service-charge of gunpowder; and, from the seventh and last experiment, we may also conclude, that it would be possible so to proportion the charge of mercurial powder to the size of different cannons, as to burst them without dispersing any splinters. But the great danger attending the use of fulminating mercury, on account of the facility with which it explodes, will probably prevent its being employed for that purpose.

"In addition to the other singular properties of the fulminating mercury (says Mr. Howard), it may be observed, that two ounces inflamed in the open air seem to produce a report much louder than when the same quantity is exploded in a gun capable of resisting its action. Mr. Cruickshank, who made some of the powder by my process, remarked that it would not inflame gunpowder. In consequence of which, we spread a mixture of coarse and fine-grained gunpowder upon a parcel of the mercurial powder; and after the inflammation of the latter, we collected most, if not all, of the grains of gunpowder. Can this extraordinary fact be explained by the rapidity of the combustion of fulminating mercury? or is it to be supposed (as gunpowder will not explode at the temperature at which mercury is thrown into vapour) that sufficient caloric is not extricated during this combustion? From the late opportunity I have had of conversing with Mr. Cruickshank, I find that he has made many accurate experiments on gunpowder; and he has permitted me to state, that the matter which remains after the explosion of gunpowder consists of potass united with a small proportion of carbonic acid, sulphate of potass, and a very small quantity of sulphuret of potass, and unconsumed charcoal. That 100 grains of good gunpowder yielded about 53 grains of this residuum, of which three are charcoal. That it is extremely deliquescent, and when exposed to the air, soon absorbs moisture sufficient to dissolve a part of the alkali; in consequence of which the charcoal becomes exposed, and the whole assumes a black or very dark colour. Mr. Cruickshank likewise informs me, that after the combustion of good gunpowder under mercury, no water is ever perceptible."

Fulmination, in the Romish canon law, a sentence of a bishop, official, or other ecclesiastic appointed by the pope, by which it is decreed, that some bull sent from the pope shall be executed.

Fulmination is also used for the denunciation, or execution of a sentence of anathema, made public with due solemnity.

FUMARIA, *fumitory*, a genus of the pentandria order, belonging to the diadelphia class of plants, and in the natural method ranking under the 24th order, corydales. The calyx is diphyllous, the corolla ringent, and there are two membranaceous filaments, each of which has three antheræ. There are a number of different species, all of them low, shrubby, and deciduous and evergreen plants, growing from two to six or seven feet high, adorned with small simple leaves, and papilionaceous flowers of different colours. The most remarkable is the officinalis or common fumitory, which grows naturally in shady cultivated grounds, and produces spikes or purplish flowers in May and June. It is very juicy, of a bitter taste, without any remarkable smell. The medical effects of this herb are, to strengthen the tone of the bowels, gently loosen the belly, and promote the urinary and other natural secretions. The old physicians recommended it in melancholic, scorbutic, and cutaneous disorders, for opening obstructions of the viscera, attenuating and promoting the evacuation of viscid juices. Frederic Hoffman had a very great opinion of it as a purifier of the blood; and assures us that in this intention scarce any plant exceeds it. Cows and sheep eat this plant; goats are not fond of; horses and swine refuse it.

FUMIGATION, in chemistry, a kind of calcination, when metals, or other hard bodies, are corroded or softened, by receiving certain fumes for that purpose.

Fumigation, in medicine and surgery, the application of fumes to particular parts of the body; as those of factitious cinnabar to venereal ulcers. See Surgery.

FUNCTION, the act of fulfilling the duties of any employment.

Function, *animal*, applied to the actions of the body, is by physicians divided into vital, animal, and natural. The vital functions are those necessary to life, and without which the individual cannot subsist; as the motion of the heart, lungs, &c. The natural functions are such as it cannot subsist any considerable time without them, as the digestion of the aliment, and its conversion into blood. Under animal functions are included the senses of touching, tasting, &c. memory, judgment, and voluntary motion, without any or all of which an animal may live, but not very comfortably.

The animal functions perform the motion of the body by the action of the muscles, and this action consists chiefly in shortening the fleshy fibres, which is called contraction, the principal agents of which are the arteries and nerves distributed in the fleshy fibres.

In short, all parts of the body have their own functions, or actions peculiar to themselves. Life consists in the exercise of these functions, and health in the free and ready exertion of them. See Physiology, Digestion, Respiration, Perspiration.

FUND, in anatomy, signifies the bottom of any cavity in the body: thus, the fund of the eye is that part possessed by the choroides and retina.

FUNDS, *public*. When the practice was first adopted of borrowing money of individuals, for defraying the extraordinary expenses of the state, the produce of some

particular tax was generally appropriated as the fund out of which the principal and interest of the debt was to be discharged. The possession of the acknowledgment given by government for the money advanced, establishing a right to receive the payments from the fund originally agreed upon, the sale of these securities was considered as a sale of the claim upon the fund, and as the acknowledgments given were of different kinds, the general appellation of the provision on which they rested was found more convenient for purposes of business: thus the sale and purchase of the government securities was commonly called the sale or purchase of the public funds, till at length the expression has so far varied from its original signification, that instead of meaning the revenue out of which public debts or the interest of them is payable, it denominates the capital of such debts, in which sense it is generally used. Variations in the saleable value of the public funds at first were caused chiefly by political events, which were supposed to affect either the authority of those by whom the debts were contracted, or the means of paying them; but since their great increase has induced many persons to make buying and selling shares therein a regular trade, the fluctuations of the current price in general depends principally on the proportion of buyers to sellers, and on the schemes and combinations in which they engage in support of their respective speculations.

The chief part of the public funds consists of perpetual annuities, or those debts on which a stipulated rate of interest is to continue to be paid, unless the principal should be redeemed; the other parts consist of annuities for a certain number of years, and life annuities. The perpetual annuities are distinguished by different titles, according to the rate of interest they pay or the time and purpose of their creation; and when government, by a loan, contracts an additional debt, bearing a certain fixed interest, it is usual to add the capital thus created to the amount of that part of the public debt which bears the same interest and denomination, and to add the produce of the taxes imposed for payment of the interest of such new debt to the fund provided for paying the interest of the former capital, thus consolidating the old and new debts, and making the interest payable out of the general produce of the same fund; hence we have 3 per cent. 4 per cent. and 5 per cent. consolidated annuities. The reduced 3 per cent. annuities take their title from having originally consisted of sums which had been borrowed at higher rates of interest, and reduced at different periods to 3 per cent. The navy 5 per cents are so called from having been created by funding navy and victualling bills. The long annuities have been granted at different periods, and for different terms, but all extended to 5th January 1806. The short annuities expired 5th January 1808. The imperial 3 per cent. annuities, and annuities for 25 years, arose from loans to the emperor of Germany, the dividends on which are guaranteed by the government of this country.

The public funds were formerly all payable and transferrable at the exchequer; but, except a few annuities, of which the term is nearly expired, and some life and tontine annuities, they are all now payable at the Bank or South Sea house.

The funds transferrable at the Bank of England are at present the following, viz.

	Transfer days	Dividends due.
5 per cent. navy ann.	Monday, Wednesday, and Friday	Jan. 5. and July 5.
3 per cent. consols	Tuesday, Wednesday, Thurs. and Frid.	
3 per cent. 1726	Tuesday and Thursday	
3 per cent. deferred	Monday, Wednesday, and Friday	April 5 and Oct. 10.
Bank-stock	Tuesday, Thursday, and Friday	
5 per cent. 1797 and 1802	Tuesday, Thursday, and Friday	
4 per cent. consols	Tuesday, Thursday, and Saturday	
3 per cent. reduced	Tuesday, Wednesday, Thurs. and Frid.	
Long annuities	Monday, Wednesday, and Saturday	
Short annuities	Monday, Wednesday, and Saturday	
3 per cent. imperial ann.	Monday, Wednesday, and Friday	May 1 and Nov. 1.
Imperial annuity, 25 years	Tuesday, Thursday, and Saturday	
Irish 5 per cent.	Tuesday, Thursday, and Saturday	Mar. 25 & Sept. 25.
Irish annuities	Tuesday, Thursday, and Saturday	
Transferable at the South-Sea house.		
South-Sea stock	Monday, Wednesday, and Friday	Jan. 5. and July 5.
3 per cent. new S. S. ann.	Tuesday, Thursday, and Saturday	
3 per cent. 1751	Tuesday and Thursday	
3 per cent. old S. S. ann.	Monday, Wednesday, and Friday	April 5 & Oct. 10.

The dividend payable to the proprietors of bank-stock is 7 per cent.; on South-Sea stock $3\frac{1}{2}$ per cent. Indian stock can no longer be classed among the public funds, as the debt due from the public to the company was cancelled on the last renewal of their charter, the dividend payable to the proprietors is $10\frac{1}{2}$ per cent. Transfers of stock in any of the government funds, if made on the appointed transfer days, are free from any expense to the parties, but the same stock cannot be transferred twice on the same day. The person who transfers property in the funds, or his broker, must be known to the witnessing clerk, or some person known must be produced to vouch for his being the identical person he is represented to be. The seller's receipt should be kept by the buyer, as a voucher for the transfer, till one dividend has been received.

Dividends on bank-stock, South-sea stock, and India-stock, after acceptance, are payable to a written order; but those respecting India-stock are payable the day after they become due; but the dividends on the stock of other companies, and on the government funds, are not payable till about a week after. The space between the shutting and opening the books of any stock is usually

about six weeks. At the time of shutting, the dividends due are carried to a separate account, and cannot be transferred with the stock of a proprietor, the warrants being filled up in the name the stock stands in when the books shut, and of course are payable only to him or his attorney. All letters of attorney, to sell or accept stock or to receive dividends, should be taken out at the respective offices, in order that the description may exactly accord with that in the bank-books, and there must be a separate letter of attorney for each different stock. Letters to sell must be deposited in the proper office prior to sale, as must also probates of wills, till registered. Acting personally, after granting a letter of attorney, revokes the power of the letter. Any one trustee after the acceptance of the whole trust, may receive dividends; and, upon the death of any of the trustees being proved by producing their wills or a certificate of burial, the survivor may transfer the stock.

Persons having occasion to invest money in the public funds generally employ a broker, to whom the party must give his name, place of abode, and usual addition, with the sum intended to be purchased. The broker soon finds a seller of the sum wanted; and having agreed upon the rate per cent. to be paid, according to the current price of the day, the particulars of the bargain are delivered to a clerk in the office in the Bank in which the description of stock intended to be purchased is transferrable. The clerk on finding that such stock stands in the seller's name, fills up a form of transfer, which is signed by the seller, conveying all his right and title to the stock to the purchaser, his heirs or assigns. A form of acceptance is then signed by the purchaser, and the seller having given him a receipt expressing the consideration paid, which is witnessed by the bank-clerk, the business is concluded.

As the prices of the several funds are continually fluctuating, and there is frequently a considerable difference in the interest produced by investing money in different funds, the following table of the prices which each fund should be at to produce an equal interest, will be found very useful to persons investing their money in these securities.

TABLE

Shewing the Comparative Value per Cent. of the several Public Funds, and the Annual Interest produced by L.100 invested at different Prices.

3 per Cents	4 per Cents.	5 per Cents.	Bank Stock, 7 per c.	Ind. St. 10½ per Cent.	Annual Interest.
45	60	75	105	157½	6 13 4
45¾	61	76¼	106¾	160⅛	6 11 1
46½	62	77½	108½	162¾	6 9 0
47¼	63	78¾	110¼	165⅜	6 6 11
48	64	80	112	168	6 5 0
48¾	65	81¼	113¾	170⅝	6 3 0
49½	66	82½	115½	173¼	6 1 2
50¼	67	83¾	117¼	175⅞	5 19 4
51	68	85	119	178½	5 17 7
51¾	69	86¼	120¾	181⅛	5 15 11
52½	70	87½	122½	183¾	5 14 3
53¼	71	88¾	124¼	186⅜	5 12 8
54	72	90	126	189	5 11 1
54¾	73	91¼	127¾	191⅝	5 9 6
55½	74	92½	129½	194¼	5 8 1
56¼	75	93¾	131¼	196⅞	5 6 7
57	76	95	133	199½	5 5 3
57¾	77	96¼	134¾	202⅛	5 3 10
58½	78	97½	136½	204¾	5 2 6
59¼	79	98¾	138¼	207⅜	5 1 3
60	80	100	140	210	5 0 0
60¾	81	101¼	141¾	212⅝	4 18 9
61½	82	102½	143½	215¼	4 17 6
62¼	83	103¾	145¼	217⅞	4 16 4
63	84	105	147	220½	4 15 2
63¾	85	106¼	148¾	223⅛	4 14 0
64½	86	107½	150½	225¾	4 13 9
65¼	87	108¾	152¼	228⅜	4 11 11
66	88	110	154	231	4 10 10
66¾	89	111¼	155¾	233⅝	4 9 10
67½	90	112½	157½	236¼	4 8 10
68¼	91	113¾	159¼	238⅞	4 7 10
69	92	115	161	241½	4 6 11
69¾	93	116¼	162¾	244⅛	4 6 0
70½	94	117½	164½	246¾	4 5 1
71¼	95	118¾	166¼	249⅜	4 4 2
72	96	120	168	252	4 3 3
72¾	97	121¼	169¾	254⅝	4 2 5
73½	98	122½	171½	257¼	4 1 7
74¼	99	123¾	173¼	259⅞	4 0 9
75	100	125	175	262½	4 0 0

Table of all the intermediate prices, and for comparing the value of the terminable Annuities with the other Funds, are given in Fairman's Guide to Purchasers in the Public Funds. Some useful information respecting the Funds, and the mode of transacting business at the Bank and Stock Exchange, will also be found in Mortimer's Every Man his Own Broker.

FUNDAMENTAL NOTE, in music, the principal note in a song, or composition, to which all the rest are in some measure adapted. and by which they are swayed: it is otherwise called the key to the song.

FUNERAL EXPENSES, are allowed previous to all other debts and charges; but if the executor or administrator be extravagant, it is a species of devastation or waste of the substance of the deceased, and shall only be prejudical to himself and not to the creditors or legatees of the deceased. 2 Bl. 508.

But in strictness, no funeral expenses are allowed against a creditor, except for the shroud, coffin, ringing the bell, parson, clerk, grave-digger, and bearers' fees, but not for pall or ornaments. 1 Salk 190.

And in general it is said, that no more than 40*s.* in the whole for funeral expenses, shall be allowed against creditors. 3 Atk. 249.

FUNGI, from σφογγος, fungus, the name of the 4th order of the 24th class of vegetables, in the Linnæan system; comprehending all those which are of the mushroon kind, and which, in Tournefort, constitute the 2d, 3d, 4th, 5th, 6th, 7th, and 8th genera of the first section in the class xvii. This order in Linnæus contains 10 genera. See AGARICUS, BOLETUS, CLAVARIA, LYCOPERDON, &c.

The ancients called fungi children of the earth, meaning, no doubt, to indicate the obscurity of their origin.

The moderns have likewise been at a loss in what rank to place them; some referring them to the animal, some to the vegetable, and others to the mineral kingdom. Messrs. Wilck and Munchausen have not scrupled to rank these bodies in the number of animal productions; because when fragments of them or their seeds were macerated in water, these gentlemen perceived a quantity of animalcules discharged, which they supposed capable of being changed into the same substance. It was the ancient opinion that beef could produce bees; but it was reserved for Messrs. Wilck and Munchausen to suppose, that bees could produce beef. Wilck asserts, that fungi consist of innumerable cavities, each inhabited by a polype; and he ascribes the formation of them to their inhabitants, in the same way as it has been said that the coral, the lichen, and the mucor were formed. Hedwig has lately shown how ill founded this opinion is with respect to the lichen; and M. Durande has demonstrated its falsity with regard to the corallines. "Indeed (says M. Bonnet, talking of the animality of fungi) nothing but the rage for paradox could induce any one to publish such a fable; and I regret that posterity will be able to reproach our times with it. Observation and experiment should enable us to overcome the prejudices of modern philosophy, now that those of the ancient have disappeared and are forgotten."

It cannot be denied that the mushroom is one of the most perishable of all plants, and it is therefore the most favourable for the generation of insects. Considering the quickness of its growth, it must be furnished with a power of copious absorption; the extremities of its vessels must be more dilated than in other plants. Its root seems, in many cases, to be merely intended for its support; for some species grow upon stones or moveable sand, from which it is impossible that they can draw much nourishment. We must therefore suppose, that it is chiefly by the stalk that they absorb. These stalks grow in a moist and tainted air, in which float multitudes of eggs, so small, that the very insects they produce are with difficulty seen by the microscope. These eggs may be compared to the particles of the byssus, 100.000 of which, as M. Gleditsch says, are not equal to the fourth of a grain. May we not suppose that a quantity of such eggs are absorbed by the vessels of the fungus, that they remain there, without any change, till the plant begins to decay?

FUNGITÆ, in natural history, a kind of fossile coral, of a conic figure, though sometimes flatted and striated longitudinally.

FUNGUS, in surgery, denotes any spongy excrescence. See SURGERY.

FURCA and FOSSA, in our old customs, the power of gallows and pit, or a jurisdiction of punishing felons, viz. the men by hanging, and the women by drowning.

FURCA, in antiquity, a piece of timber resembling a fork, used by the Romans as an instrument of punishment, which was of three kinds: the first only ignominious, when a master, for small offences, forced his servant to carry a furca on his shoulders about the city. The second was penal, when the party was led about the circus, or other place, with the furca about his neck, and whipped all the way. The third was capital, when the malefactor, having his head fastened to the furca, was whipped to death.

FURCAM, ET FLAGELLUM, the meanest of all servile tenures, the bondman being at the lord's disposal for life and limb.

FURCHE', in heraldry, a cross forked at the ends.

FURIA, in zoology, a genus of insects belonging to the order of vermes zoophyta. There is but one species, viz. the infernalis. This has a linear smooth body ciliated on each side, with reflexed feelers pressed to its body. In Finland, Bothnia, and the northern provinces of Sweden, it is not unfrequently that people are seized with a pungent pain, confined to a point, in the hand or other exposed part of the body, which presently increases to a most excruciating degree and even sometimes proves suddenly fatal. This disorder, caused by the insect dropping out of the air, and in a moment burying itself in the flesh, is relieved by a poultice of curds or cheese.

FURLING, in the sea-language, signifies the wrapping up and binding any sail close to the yard; which is done by hauling upon the clew-lines, bunt-lines, &c. which wraps the sail close together, and being bound fast to the yard, the sail is furled.

FURLONG, a long measure, equal to $\frac{1}{8}$ of a mile, or forty poles. It is also used, in some law-books, for the eighth part of an acre.

FURLOUGH, in the military language, a licence granted by an officer to a soldier, to be absent for some time from his duty.

FURNACE, an utensil to raise and maintain a vehement fire in, whether of coal or wood.

In order to apply fire, to manage and to direct it where it is to act, furnaces are convenient, and they are the most necessary and indispensable instruments to chemists. The materials of which they are constructed ought to be sufficiently proof against that degree of heat, which they are intended to be exposed to. Commonly they are built of bricks, made of sand and clay, or of cast-iron, or of iron plates, which, the better to be defended against the fire, are coated (in the inside) to the thickness of an inch with Windsor loam. According to Lewis, various kinds of fireproof furnaces, for small experiments, may be prepared from black-lead crucibles.

The burning of the fuel is kept up in the furnace either by a natural current of air, which is caused by the fire itself, and such a furnace is called an air wind-furnace; or it is done by compressed air, conveyed to the furnace by a large bellows, as in blast-furnaces.

Every wind furnace consists of two essential parts: the fire-place hearth, or that where the material destined for the fuel is placed; and the ash-pit, that receives the ashes of the consumed fuel, admits the air through its aperture (the ash-hole), and is separated from the hearth by the grate.

If the bodies to be examined are not immediately placed upon the fire, but either on iron bars, or in vessels to be heated by the fire, then a third space, the laboratory, is formed in the wind-furnace. If by the laboratory the fire-place is thoroughly closed, it must be provided with some vent-holes, or registers, to allow access of air.

Such wind-furnaces as are closed by a vaulted cover, and have either at top or on the inside, a narrow vent-

pipe. or chimney, are called reverberatory furnaces, cuppelling furnaces. Sometimes the fire-place is a part of a seprate furnace, from which, however, by the draught of air, the flame of the fuel is forced over, striking upon the hearth of the cuppelling-furnace, which then is to be considered as the laboratory.

The current of air in wind-furnaces arises from the increased elasticity of that portion of air which is contained in the upper cavity of the fire-place, it being there heated by the fire, and naturally caused to expand. When this air rises by its increased elasticity, the denser and colder air below the grate must, of course, force its way to the hearth, blow up the fire, and thus maintain the combustion. It is obvious that, the air being rarer in the upper regions of the atmosphere, the higher the chimney in a close air or wind-furnace, the stronger will be the draught; that is, the air in the upper part of the chimney being exceedingly rarefied by the heat, and the atmospheric air at the vent or upper orifice of the chimney being rarer than the air below, there will be less resistance to the stream of rarefied air. The cold and dense air from below will therefore rush violently towards the ash-pit, to restore the equilibrium, and will penetrate through the fire, which it thus furnishes with a constant supply of fresh oxygen gas (the proper food of fire), and becoming rarefied in its turn by the accession of caloric, will force its way up the chimney, and thus a continual circulation is maintained, which will support almost any degree of heat while there is a regular supply of fuel, if the chimney is of a considerable height. It is evident that the size of the ash-hole should not be too large, but bear a proportion to the height of the chimney.

The perfection of a wind-furnace therefore consists, 1, in a good current of air; 2, in keeping the heat together, without losing too great a quantity of it unused; and, 3, in the facility with which the heat may be increased or weakened. The heat in wind-furnaces is increased, partly by an additional supply of fuel, partly by accelerating the draught of air. The last is effected by opening the door of the ash-pit wider, by shutting that of the fire-place, by opening the registers, and lengthening the chimney by additional vent-pipe, and also occasionally by applying the action of the bellows. The heat again is diminished by diminishing the quantity or celerity of the current of air; hence, by shutting the ash-hole, the registers, and vent-pipes, and by the proper application of these means the action of fire is weakened, or thoroughly suppressed.

Blast-furnaces increase the heat upon the same principle, by bringing in contact with the fuel of a fresh supply of oxygen, but this being effected by mechanical means, viz. by bellows, they are of a simpler construction than wind-furnaces, and their ash-pit, hearth, and laboratory, are commonly but one and the same part. The blowing is most frequently effected by bellows, which for small experiments are always made of leather, and to act without interruption, should be double. At the smelting works, wooden bellows are used; but these being single, there are always at the same time two of them employed, alternately opening and shutting. The cylinder-bellows are a discovery of modern times, and exceed the common by many advantages. Water-drums, as they are called, may likewise serve for these purposes.

When the vessels in which bodies are exposed to the action of heat are not placed in immediate contact with the fire in the wind-furnace, but receive the required degree of heat by another intermediate body, such apparatus is called a bath. The proper instrument for this purpose is the sand-furnace, or a wind-furnace, whose upper aperture is shut by the sand-pot. Sand-pots are cylindrical vessels, having an outwardly convex bottom, and made of cast or sheet-iron, and at times of baked clay. Glass vessels, however, containing bodies that are to be exposed to heat, are not placed in the pot while empty; but in order that they may be heated uniformly, this last is filled with some other body, into which the vessels are lodged. The matter most commonly employed in this case is dry, finely sifted sand; and the pot filled with it is called a sand-bath. Of all baths the sand-bath is the most convenient, and sufficient to apply any degree, from gentle warmth to red-heat. Crucibles placed between coals, are also used for a sand-bath instead of sand-pots.

If vessels are heated by means of hot water, in which they are immersed, it is called a water-bath, balneum mariæ; but if they are heated merely by the steam of boiling water, it is called a vapour-bath. Since water boiling in the open air is capable of receiving only a determinate degree of heat, it becomes thereby a sure means to impart heat, without danger of exceeding a certain degree.

Furnace, *glass painters*, is made of brick, nearly square, and about 2½ feet each way. It is cut horizontally in the middle by a grate, which sustains the pan or shovel the glass is baked in. This furnace has two apertures, one below the grate, to put the fuel in at; the other above it, through which the workman spies how the action of the colours goes on.

Furnaces, *haiters*, are of three kinds: a little one under the mould, whereon they form their hats; a larger in the scouring-room, under a little copper, full of lees; and a very large one under the great copper, wherein they dye their hats.

FURR, in commerce, signifies the skin of several wild beasts, dressed in alum with the hair on, and used as a part of dress by princes, magistrates, and others. The kinds most in use are those of the ermine, sable, castor, hare, rabbit, &c.

Furrs, in heraldry, a bearing which represents the skins of certain beasts, used as well in the doublings of the mantles belonging to the coat-armours, as in the coat-armour themselves.

FURZE, or *furze-bush*. See Ulex.

FUSANUS, a genus of the polygamia monœcia class and order. The herm. callyx is five-cleft; corolla none; stamina four; germen inferior; stigma four drupe. Male calyx, &c. the same. Fruit abortive. There is one species, a tree of the Cape.

FUSEE, in clock-work, is that part drawn by the spring, and about which the chain or string is wound. See Clock and Watch-work.

FUSES, in artillery, according to captain George Smith, formerly inspector to the military academy at Woolwich, are chiefly made of very dry beech wood, and sometimes of horn-beam taken near the root. They are turned rough and bored at first, and then kept for

several years in a dry place. The diameter of the whole is about $\frac{3}{4}$ of an inch; the hole does not go quite through, having about $\frac{1}{4}$ of an inch at the bottom; and the head is made hollow in the form of a bowl.

The composition for fuses is, saltpetre 3, sulphur 1, and mealed powder 3, or 4, and sometimes 5. This composition is driven in with an iron driver whose ends are capped with copper, to prevent the composition from taking fire; and to keep it equally hard; the last shovel-full being all mealed powder, and 2 strands of quick match laid across each other, being driven in with it, the ends of which are folded up into the hollow top, and a cap of parchment tied over it until it is used.

FUSILEERS, in the British service, are soldiers armed like the rest of the infantry, with this difference only, that their musquets are shorter and lighter than those of the battalion and the grenadiers. They wear caps which are somewhat less, in point of height, than common grenadier caps. There are three regiments in the English service; the royal regiment of Scotch fusileers, raised in 1678; the royal regiment of Welch fusileers, raised in 1685; and the royal regiment of Welch fusileers, raised in 1688-9.

FUSILY, or *fusile*, in heraldry, signifies a field or ordinary, entirely covered over with, or divided into fusils.

FUSION, the action of fire, or more properly, of caloric, on solid bodies, by which they are caused to pass into the state of fluidity; and a body rendered liquid by fire is said to be in fusion, to flow, to melt.

From the difference between solid and fluid bodies, it follows, that the active expansive power of the caloric is the principal or true cause of fusion; since, by combining with the solid substance, it diminishes and destroys, in a high degree, the attractive force of its particles. The fluidity of all liquid bodies, we know at present, is merely derivative, and the effect of the influx of caloric.

If we attend to the different strength of the attractive power which the particles of substances, specifically different, exert on one side amongst themselves, and on the other towards the caloric, we find no ground to wonder why some bodies require a lower, others a higher, temperature to be fused; and that it is possible to meet with some bodies, which at any degree of temperature we hitherto know in our atmosphere, continue in the liquid state. According to the various degrees of fusibility, bodies are discriminated into refractory, or of difficult fusion, which require the utmost violence of fire to be melted; and simply fusible, or of easy fusion, that will flow in less heat; yet the limits between these have not yet been ascertained by any fixed scale.

Some mixtures melt with greater ease than the single substances of which they are composed.

Some bodies cannot be rendered fluid by any degree of heat which we are able to produce. These are called infusible, apyrous or fire-proof. Several of them may, however, be fused by adding other bodies, which on account of this property are called fluxes. Such addition is called at the smelting-works dressing of the ores. It is worth remarking, that sometimes these additions are of themselves infusible.

The true fusion ought not to be confounded with the melting of some salt crystals by heat. The last is caused by the aqueous particles contained in them dissolving the salt at an increased heat, which they cannot at a weaker.

When melted bodies, by a circumambient medium of a lower temperature, are deprived of so much caloric that the original attractive forces of the bodies of which they are compounded, acquire again the degree of intensity requisite to produce the form of solidity; or when by this loss of caloric, the native attraction among the surfaces of the primitive molecules becomes again active, they concrete, or congeal.

All bodies must, in consequence of the explanation given of fusion, assume in fusion a greater volume than that which they had in their former state of solidity. This is in every respect confirmed by experience. The exception which some bodies, as ice, bismuth, antimony sulphur, seem to make, may be easily explained by the crystallization of their parts on concreting.

Since no solution takes place without liquidity, fusion becomes one of the most effectual operations for solutions and precipitations in the dry way. Fusion is, besides, of importance in separating heterogeneous parts simply mingled by means of their different degrees of fusibility; as also by the circumstance, that various shapes may be given to bodies by casting them into moulds while in a fluid state.

Fusion is sometimes performed without any vessel at all, and then in small quantities, by the flame of a candle or lamp, with the assistance of the blow-pipe: but, in larger quantities, by placing the bodies to be fused amongst the coals in a melting furnace. At other times, the operation is done in vessels, subjected to the requisite heat, in the furnace.

When the blow-pipe made of glass or metal, is employed, the air compressed by the mouth is directed on the flame; and the heat, by that means increased, is communicated to the substance to be fused, which generally rests on a support, in a cavity made in a lump of charcoal. The apparatus by which the air is made to stream through the blow-pipe, by means of double bellows, renders this useful instrument capable of being employed by persons whose lungs do not permit them to continue the blowing long, or who are not sufficiently skilled in its management. Lastly, the heat of a lamp-flame may be raised to the highest degree, by conducting oxygen gas through the blow-pipe, by means of a peculiar apparatus.

In smelting-houses, the fusion without vessels is performed in a very simple way, by placing the substances to be fused immediately betwixt burning charcoal in the melting-furnaces. In these the fusion is urged by bellows; and they are of various constructions, to suit a variety of purposes. Hence also they have received different denominations.

Other kinds of fusion, especially in small quantities, are performed in vessels of various shape and materials. Their most essential properties, are their being infusible at any degree of heat required for melting the bodies to be fused in them; and, besides, their insolubility in that body when melted.

FUSTIAN, in commerce, a kind of cotton stuff, which seems as if it was whaled on one side.

FUTTOCKS, in a ship, the timbers raised over the keel, or the encompassing timbers that make her breadth.

Of these are first, second, third, and fourth, denominated according to their distance from the keel, those next it being called first or ground futtocks, and the others upper futtocks: those timbers, being put together, make a frame-bend.

G.

G, the seventh letter of our alphabet; as a numeral was anciently used to denote 400; and with a dash over it thus, $\overline{G}$, 40,000. In music it is the character or mark of the treble cliff; and from its being placed at the head, or marking the first sound in Guido's scale, the whole scale took the name gamut. As an abbreviature, G. stands for Gaius, Gellius, gens, genius, &c. G. G. for gemina, gessit, gesserunt, &c. G. C. genio civitatis, or Cæsaris. G. L. for Gaius libertus, or genio loci. G. V. S. for genio urbis sacrum. G. B. for genio bono. And G. T. for genio tutelari.

GABARA, or *gabbara*, in antiquity, the dead bodies which the Egyptians embalmed, and kept in their houses, especially those of such of their friends as died with the reputation of great piety and holiness, or as martyrs.

GABEL, a word met with in old records, signifying a tax, rent, custom, or service, paid to the king, or other lord.

GABIONS, in fortification, baskets made of ozier-twigs, of a cylindrical form, six feet high, and four wide; which being filled with earth, serve as a shelter from the enemy's fire. See FORTIFICATION.

GABRES, or *gaurs*, in the religious custom of Persia. See Gaurs.

GAD, among miners, a small punch of iron, with a long wooden handle, used to break up the ore. One of the miners holds this in his hand, directing the point to a proper place, while the other drives it into the vein, by striking it with a sledge-hammer.

GAD-FLY, or *breeze-fly*. See OESTRUS.

GADOLINITE, a mineral first found in a white felspar in the quarry of Ytterby in Sweden, and received the name gadolinite, because Gadolin was the chemist who first ascertained its composition. Colour perfect black, passing sometimes to brown. Found in mass. Fracture conchoidal. Scratches quartz. Brittle. Specific gravity 4.0497. Gelatinizes with hot diluted nitric acid. Before the blow-pipe decrepitates, and assumes a whitish-red colour, but does not melt. With borax it melts into a topaz-yellow glass. Affects the magnetic needle. According to the Vanalysis of auquelin, it is composed of.

35.0	yttria
25.5	silica
25.0	oxide of iron
2.0	lime
2.0	oxide of manganese
10.5	water and carbonic acid
100.0	

Klaproth, on the other hand, found

59.75	yttria
21.25	silica
18.00	oxide of iron
0.50	alumina
99.50	

This last analysis does not differ much from that which Ekeberg had before published.

GADUS, cod, in ichthyology, a genus of fishes belonging to the order of jugulares. The generic character is, head smooth; gill-membrane, seven-rayed; body oblong, covered with deciduous scales; fins all covered by the common skin; dorsal and anal generally more than one; the rays unarmed; ventral fins slender, ending in a point. There are 17 species, the principal of which are,

1. Gadus morhua, or common cod. This highly important and prolific species, which furnishes employment for so many thousands, and forms so considerable a part of the subsistence of mankind, is an inhabitant of the northern seas, where it resides in immense shoals, performing various migrations at stated seasons, and visiting in succession the different coasts of Europe and America. Its history is so well detailed by Mr. Pennant, that little can be added to what that author has collected in his British and Arctic Zoology.

"The general rendezvous of the cod-fish," says Mr. Pennant, "is on the banks of Newfoundland, and the other sand-banks that lie off the coasts of Cape Breton, Nova Scotia, and New England. They prefer those situations on account of the quantity of worms produced in those sandy bottoms, which tempt them to resort thither for food; but another cause of this particular attachment to those spots is their vicinity to the polar seas, where they return to spawn: there they deposit their roe in full security, but want of food forces them, as soon as the first more southern seas are open, to repair thither for subsistence. Few are taken north of Iceland, but on the south and west coasts they abound: they are again found to swarm on the coasts of Norway, in the Baltic, off the Orkney and the Western isles; after which their numbers decrease, in proportion as they advance towards the south, when they seem quite to cease before they reach the mouth of the Straits of Gibraltar."

Before the discovery of Newfoundland, the greater fisheries of cod were on the seas of Iceland and our own Western isles, which were the grand resort of the ships of all the commercial nations; but it seems that the greatest plenty was met with near Iceland.

Newfoundland, a name in the infancy of discovery common to all North America, was discovered in the year 1496, by the celebrated Venetians, Sebastian Cabot and his three sons; who, at their own charges, under a grant of Henry the seventh, giving them possession, as vassals of his, of all lands they might discover, coasted from lat. 67° 30′ to the Cape of Florida.

The isle of Newfoundland is of a triangular form, and lies between lat. 46° 40′ and 51° 30′: visited occasionally, but not inhabited, by savages from the continent. The boasted mine of this land, viz. its sand-bank, is represented as a vast sub-marine mountain, of above 500 miles long, and near 300 broad, and seamen know when they approach it by the great swell of the sea, and the thick

mists that impend over it. The water on the bank is from twenty-two to fifty fathoms; on the outside from sixty to eighty; and on the smaller banks much the same: the increase of shipping that resort to these fertile banks is now unspeakable: England still enjoys the greatest share, and it ought to be esteemed one of it chiefest treasures, bringing wealth to individuals, and strength to the state. All this immense fishery is carried on by the hook and line only: the principal baits are herring, the small fish called a capelin, the shell-fish called clams, and pieces of sea-fowl; and with these are caught sufficient to find employ for fifteen thousand British seamen, and to afford subsistence to a much more numerous body of people at home, who are engaged in the various manufactures which so vast a fishery demands. The fish, when taken, are properly cleaned, salted, and dried, and in this state sent into various parts of the European continent.

The cod grows to a very large size. Mr. Pennant commemorates a specimen taken on the British coast which weighed 78 lbs. and measured 5 feet 8 inches in length, and 5 feet in girth round the shoulders; but the general size, at least in the British seas, is far less, and the weight from about 14 to 40 pounds; and such as are of middling size are most esteemed for the table.

The cod is of a moderately long shape, with the abdomen very thick and prominent: the head is of a moderate size, and the eyes large: the jaws of equal length, the lower one bearded at the tip by a single cirrus; in the jaws and palate are numerous sharp teeth: the dorsal and anal fins are rather large, the pectoral rather small: the ventral small and slender: the tail of moderate size and even at the end, the first ray on each side being short, strong, and bony. The usual colour of this fish is cinereous on the back and sides, and commonly spotted with dull yellow: the belly white or silvery; but the colours occasionally vary very considerably, and instances are often seen in which a yellow, orange, or even red tint prevails on the upper parts of the body, while the spots are lighter or deeper according to the different seasons in which the fish is taken: the lateral line, which is one of the principal distinctive marks of the species, is broad and whitish, and the scales are somewhat larger than in others of the genus.

The food of the cod is either small fish, worms, testaceous or crustaceous animals, such as crabs, large whelks, &c. its digestion is so powerful as to dissolve the greatest part of the shells it swallows; it is very voracious, catching at any small body it perceives moved by the water, even stones and pebbles, which are often found in the stomach. The fishermen are well acquainted with the use of the air bladder or sound of this fish, and dexterously perforate the living fish with a needle, in order to let out the air contained in that part; for without this operation the fish could not be kept under water in the well-boats, and brought fresh to market. The sounds when salted, are reckoned a delicacy, and are often brought in this state from Newfoundland. A species of isinglass is also prepared from this part of the fish by the natives of Iceland.

2. Gadus æglefinus, or haddock, is distinguished from the rest of this genus by having a forked tail, and the lower jaw longer than the upper: the colour of the body is silvery or white, with a dusky cast on the back: the lateral line is black, and on each side at some distance beyond the head, and above the pectoral fins, is a moderately large, squarish black spot: the tip of the lower jaw is furnished with a cirrus: the eyes are large; the scales small, round, and pretty closely attached to the skin.

This species is a native of the northern seas, where, like the cod, it assembles in prodigious shoals, visiting particular coasts at stated seasons; the shoals are sometimes near six miles in length, and more than a mile in breadth. "The grand shoal of haddocks," says Mr. Pennant, "comes periodically on the Yorkshire coasts. It is remarkable that they appeared in 1766 on the 10th of December, and exactly on the same day 1767. These shoals extended from the shore near three miles in breadth, and in length from Flamborough Head to Tinmouth castle, and perhaps much farther northwards. An idea may be given of their numbers by the following fact: three fishermen within the distance of a mile from Scarborough harbour frequently loaded their coble or boat with them twice a day, taking each time about a ton of fish: when they put down their lines beyond the distance of three miles from the shore they caught nothing but dog-fish, which shows how exactly these fish keep their limits. The best were sold from eight pence to a shilling per score, and the poor had the smaller sort at a penny, and sometimes a halfpenny per score." The haddock is taken in vast quantities about Heligoland, and thence sent to Hamburgh. In stormy weather this fish is said to imbed itself in the ooze at the bottom of the sea, none being taken in such weather; and those which are taken afterwards are observed to be covered with mud on their backs.

The haddock is, in general, of moderate size, measuring about eighteen inches or two feet in length: those which are most esteemed for the table weighing from two to four pounds; but it sometimes arrives at the length of three feet, and the weight of fourteen pounds. Its food consists of small fishes, worms, and sea-insects. It spawns in the month of February.

3. Gadus callarias, or dorse, is a somewhat smaller species than the haddock, those which are usually taken rarely exceeding the weight of two pounds.

The head is smaller than that of the haddock, and is marked by several spots, which in the summer are generally brown, and in the winter black: the general colour of the fish is cinereous above, and white beneath, several brown spots being scattered over the body, which, in the young fish, are often of an orange-colour: the scales are small, thin, and soft: the upper jaw is longer than the lower, and is furnished with more rows of teeth: at the tip of the lower jaw is a cirrus or beard.

The dorse is a native of the northern seas, as well as of the Mediterranean and the Baltic. It is taken both by the line and the net, and is highly esteemed as an article of food. It lives, like most others of this genus, on the smaller fishes, and sea-insects. Instances are adduced by authors in which this fish, like the haddock, has been found greatly to exceed the usual size, and to weigh seven, eight, ten, or even fourteen pounds. It spawns in the month of February.

4. Gadus barbatus, or whiting-pout, according to Mr. Pennant, never grows to a large size, rarely exceeding a foot in length, and is distinguished from all others by its great depth; one of the size above mentioned being near four inches deep in the broadest part: the back is very much arched, and carinated: the scales larger than those of the cod-fish: the mouth small, and the head short, on each side the lower jaw are seven or eight punctures: the first dorsal fin is triangular, and terminates in a long fibre: the colour of the fins and tail are dusky or blackish, and at the bottom of the pectoral fins is a black spot: the body is white, but more obscure on the back than the belly, and tinged with yellow: the lateral line is white, broad, and crooked. This fish is in high estimation as a food, and is found in the Mediterranean and northern seas.

5. Gadus minutus, or poor, is a small species, seldom exceeding six or seven inches in length, and of a more slender form than any of the preceding kinds. It is found in the Baltic and the Mediterranean, as well as in some parts of the northern seas. Its appearance in the Mediterranean, is considered by the fishermen as the precursor of the cod, and the haddock, of which it is supposed to indicate very plentiful shoals. It is reckoned a wholesome food, and is taken both by the line and net. It is supposed to feed chiefly on worms and sea-insects, and deposits its spawn among the stones and sea-plants towards the borders of the shore.

6. Gadus merlangus, or whiting, with three dorsal fins, as in the preceding kinds, but with a beardless mouth. The whiting is, according to Mr. Pennant, the most delicate as well as the most wholesome of the genus, but does not grow to a large size, the usual length being about ten or twelve inches, and the largest scarcely exceeding that of twenty. It is a fish of an elegant make: the body is rather long, and covered with small, round silvery scales: the head and back are of a pale brown, and the sides slightly streaked with yellow. This fish is an inhabitant of the Baltic, and the northern seas, and is found in some parts of the Mediterranean. Vast shoals appear in the British seas during the spring; keeping at the distance of from about half a mile to that of three from the shore; they are caught in vast numbers by the line, and afford excellent diversion: their food consists of small fishes, sea insects and worms: they are said to be particularly fond of sprats and young herrings, with which the fishermen generally bait for them, and in defect of these with pieces of fresh herring, one being sufficient, when cut, for twenty baits. According to Dr. Bloch, the chief time of the whiting fishery in France is in the months of January and February, though in England and Holland it is practised at a much later period. It spawns in December and January.

7. Gadus carbonarius, or coal-fish, when full grown, is, in general, readily distinguished from its congeners by its very dark or black colour, though in this respect it sometimes varies: it is of a moderately long and elegant shape, with a small head, sharpened snout, and lower jaw exceeding the upper in length: when full grown the head, dorsal fins, tail and upper parts of the body are of a dusky black, which gradually softens into a silvery tinge as it approaches the abdomen. It is an inhabitant of the Baltic, the northern and Mediterranean seas: it is common on the most of our rocky and deep coasts, but particularly on those of Scotland and the Orkneys, where, according to Mr. Pennant, it swarms, and where the young or fry forms a great part of the support of the poor.

8. Gadus merluccius, or hake, with two dorsal fins. The hake is of a considerably lengthened form: the head is rather large, broad and flat at the top, but compressed on the sides; the opening of the mouth wide, and the jaws armed with two rows of long, sharp-pointed, curved teeth, intermixed alternately with smaller ones: the palate is also furnished with a row of teeth on each side; the pectoral and ventral fins are of moderate size, and of a sharpened shape, and the tail is nearly even at the end; the lateral line commences by several small warts beyond the head, and is continued in a straight direction to the tail: the usual length of the hake is from one to two feet, but it is sometimes found of the length of three feet.

This fish is an inhabitant of the Mediterranean and northern seas, in both of which its fishery is very considerable: it is salted and dried in the manner of cod, haddock, &c. but is not considered as a delicate fish, either in its fresh or salted state, and is rarely admitted to the tables of the rich and luxurious: it forms however a very useful article of food for the lower orders in many parts both of England and other countries. It is found in vast abundance on many of the coasts of England and Ireland. We are informed by Mr. Pennant that there was formerly a vast stationary fishery of the hake on the Nymph Bank, off the coast of Waterford, immense quantities appearing there twice a year; the first shoal coming in June, during the mackarel season, and the other in September, at the beginning of the herring season, probably in pursuit of those fish: it was no unusual thing for six men with hooks and lines to take a thousand hake in one night, besides a considerable quantity of other fish. At present, as we are informed by Dr. Bloch, one of the greatest hake-fisheries is carried on about the coasts of Britanny, both by the hook and net. It is carried on chiefly by night, in boats properly manned for the purpose: the principal baits for such as are taken by the line are launces, sardines, and other small fishes.

9. Gadus molva, or the ling, takes its name from its length, being corrupted from the word long: the body is very slender; the head flat. The usual size of the ling is from three to four feet, but is said to have been sometimes seen of the length of seven feet: in colour it varies, being sometimes of an olive hue on the sides and back, and sometimes cinereous: the abdomen is white, as are also the ventral fins, and the dorsal and anal are edged with white: the tail is marked near the end with a transverse black bar, and tipped with white.

The ling is an inhabitant of the northern seas, and forms in many places a considerable article of commerce. It chiefly frequents the depths of the sea, living on small fishes, shrimps, &c. It spawns in June, depositing its eggs among the fuci on the oozy bottoms. In the Yorkshire seas the ling is in perfection from the beginning of February to the beginning of May, and some till the end of that month: as long as they continue in season the liver is very white, and abounds with fine flavoured oil; but as soon as the fish goes out of season the liver becomes red, and affords no more oil: the same circumstance is obser-

vable in several other fish in a certain degree, but not so remarkably as in the ling.

Vast quantities of this fish are salted for exportation as well as for home consumption. When it is cut or split for curing it must measure twenty-six inches, or upwards, from the shoulder to the tail; if less than that it is not reckoned a sizeable fish, and consequently not entitled to the bounty on exportation.

11. Gadus lota, or the burbot, highly esteemed for its superior delicacy, is an inhabitant of clear lakes and rivers, and is found in many parts of Europe and Asia. In England it occurs chiefly in the lakes of the northern counties, in some of the fens of Lincolnshire, and the rivers Witham and Trent; but it is said to arrive at its greatest perfection in the Lake of Geneva, where it is found in great plenty. In its habit or general appearance the barbot makes an obscure approach to the muræna, having a remarkably lengthened body of a subcylindric shape.

The burbot is considered as a very voracious fish, preying on all the smaller fishes, as well as on frogs, worms, and aquàtic insects: it grows to a considerable size: the largest however of those which are taken in England have been rarely known to exceed the weight of three pounds, but in some parts of Europe they are found of more than double that weight, and of the length of three feet or more. The reputation of this fish as a food has long been established, but its liver is celebrated as an article of peculiar luxury; and we are informed by Aldrovandus, that an old German countess carried her epicurism so far as to expend the greatest part of her income in the purchase of this dish. The gall has been famed, like that of the stargazer, the barbel, and some other fishes, for its supposed efficacy in external disorders of the eyes.

GÆRTNERE, a genus of the decandria monogynia class and order. The calyx is five-parted; corolla five-petalled; seed-vessel nearly globose, with wings. There is one species, a shrub of the East Indies.

GAGE, in law-books, the same with surety or pledge.

Gage, in the sea-language. When one ship is to windward of another, she is said to have the weather-gage of her. They likewise call the number of feet that a vessel sinks in the water, the ship's gage: this they find by driving a nail into a pike near the end, and putting it down beside the rudder till the nail catches hold under it; then as many feet as the pike is under water, is the ship's gage.

Gage, among letter-founders, a piece of box, or other hard wood, variously notched; the use of which is to adjust the dimensions, slopes, &c. of the different sorts of letters. There are several kinds of these gages, as the flat-gage, the face-gage, and italic-gage, &c.

Gage, *sliding*, a tool used by mathematical instrument-makers, for measuring and setting off distances. It is also of use in letter-cutting, and making of moulds.

Gage, *sea*, an instrument invented by Dr. Hayles, and Dr. Desaguliers, for finding the depth of the sea, the description of which is this. A B, (Plate LXIV. fig. 96. Miscel.) is the gage-bottle, in which is cemented the gage-tube E *f*, in the brass-cap at G. The upper end of the tube E, is hermetically sealed, and the open lower end *f*, is immersed in mercury, marked C, on which swims a small thickness or surface of treacle. On the top of the bottle is screwed a tube of brass H G, pierced with several holes, to admit the water into the bottle A B. The body K, is a weight, hanging by its shank L, in a socket N, with a notch on one side at *m*, in which is fixed the catch *l* of the spring *s*, and passing through the hole L, in the shank of the weight K, prevents its falling out, when once hung on. On the top, in the upper part of the brass-tube at H, is fixed a large empty ball, or full-blown bladder I, which must not be so large, but that the weight K may be able to sink the whole under water.

The instrument, thus constructed, is used in the following manner. The weight K being hung on, the gage is let fall into deep water, and sinks to the bottom; the socket N, is somewhat longer than the shank L, and therefore, after the weight K comes to the bottom, the gage will continue to descend, till the lower part of the socket strickes against the weight; this gives liberty to the catch to fly off the hole L, and let go the weight K; when this is done, the ball or bladder I, instantly buoys up the gage to the top of the water. While the gage is under water, the water having free access to the treacle and mercury in the bottle, will by its pressure force it up into the tube E *f*, and the height to which it has been forced by the greatest pressure, viz. that at the bottom, will be shown by the mark in the tube which the treacle leaves behind it, and which is the only use of the treacle. This shows into what space the whole air in the tube E *f* is compressed; and consequently the height or depth of the water, which by its weight produced that compression, which is the thing required.

If the gage-tube E *f*, is of glass, a scale might be drawn on it with a point of a diamond, showing by inspection, what height the water stands above the bottom. But the length of 10 inches is not sufficient for fathoming depths at sea, since that, when all the air in such a length of tube is compressed into half an inch, the depth of water is not more than 634 feet, which is not half a quarter of a mile.

If to remedy this, we make use of a tube 50 inches long, which for strength may be a musquet-barrel, and suppose the air compressed into an hundreth part of half an inch; by saying as 1 : 99 : : 400 : 396000 inches, or 3300 feet: even this is but little more than half a mile, or 2640. But since it is reasonable to suppose the cavities of the sea bear some proportion to the mountainous parts of the land, some of which are more than three miles above the earth's surface, therefore, to explore such great depths, the Doctor contrived a new form for his sea-gage, or rather for the gage-tube in it, as follows: B C D F (fig. 97.) is a hollow metallic globe communicating on the top with a long tube A B, whose capacity is a ninth part of that globe. On the lower part at D, it has also a short tube D E, to stand in the mercury and treacle. The air contained in the compound gage-tube is compressed by the water as before; but the degree of compression, or height to which the treacle has been forced, cannot here be seen through the tube; therefore, to answer that end, a slender rod of metal or wood, with a knob on the top of the tube A B, will receive the mark of the treacle, and show it, when taken out.

If the tube A B be 50 inches long, and of such a bore

that every inch in length shall be a cubic inch of air, and the contents of the globe and tube together 500 cubic inches; then, when the air is compressed within an hundredth part of the whole, it is evident the treacle will not approach nearer than 5 inches of the top of the tube, which will agree to the depth of 3300 feet of water as above. Twice this depth will compress the air into half that space nearly, viz. $2\frac{1}{2}$ inches, which correspond to 6600, which is a mile and a quarter. Again, half that space, or $1\frac{1}{4}$ inch, will show double the former depth, viz. 13200 feet, or $2\frac{1}{2}$ miles, which is probably very nearly the greatest depth of the sea.

*Bucket-sea-*Gage, an instrument contrived by Dr. Hales, to find the different degrees of coolness and saltness of the sea, at different depths; consisting of a common houshold pail or bucket, with two heads to it. These heads have each a round hole in the middle, near four inches diameter, and covered with valves opening upwards; and that they might both open and shut together, there is a small iron-rod fixed to the upper part of the lower valve, and at the other end to the under part of the upper valve: so that as the bucket descends with its sinking weight into the sea, both the valves open by the force of the water, which by that means has a free passage through the bucket. But when the bucket is drawn up, then both the valves shut by the force of the water at the upper part of the bucket; so that the bucket is brought up full of the lowest sea-water to which it had descended.

When the bucket is drawn up, the mercurial thermometer, fixed in it, is examined; but great care must be taken to observe the degree at which the mercury stands, before the lower part of the thermometer is taken out of the water in the bucket, else it would be altered by the different temperature of the air.

In order to keep the bucket in a right position, there are four cords fixed to it, reaching about four feet below it, to which the sinking weight is fixed.

*Wind-*Gage, an instrument for measuring the force of the wind upon any given surface. It was invented by Dr. Lind, who gives the following description of it, Phil. Trans. vol. lxv. This instrument consists of two glass tubes, A *a*, C D, Plate LXIV. Miscel. fig. 98. of five or six inches in length. Their bores, which are so much the better for being equal, are about four-tenths of an inch in diameter. They are connected together like a siphon, by a small bent glass-tube marked *a b*, the bore of which is about one-tenth of an inch in diameter. On the upper end of the leg A *a* there is a tube of latten brass, which is kneed or bent perpendicularly outwards, and has its mouth open towards F. On the other leg C D is a cover with a round hole G in the upper part of it, two-tenths of an inch in diameter. This cover and the kneed tube are connected together by a slip of brass *c d*, which not only gives strength to the whole instrument, but also serves to hold the scale H I. The kneed tube and cover are fixed on with hard cement or sealing-wax. To the same tube is soldered a piece of brass *e*, with a round hole in it to receive the steel spindle K L; and at *f* there is just such another piece of brass soldered to the brass-hoop *g*, which surrounds both legs of the instrument. There is a small shoulder on the spindle at *f*, upon which the instrument rests, and a small nut at *i*, to prevent it from being blown off the spindle by the wind. The whole instrument is easily turned round upon the spindle by the wind, so as always to present the mouth of the kneed tube towards it. The end of the spindle has a screw on it, by which it may be screwed into the top of a post or a stand made on purpose. It has also a hole at L, to admit a small lever for screwing it into wood with more readiness and facility. A thin plate of brass *k* is soldered to the kneed tube, about half an inch above the round hole G, so as to prevent rain from falling into it. There is likewise a crooked tube A B, fig. 99, to be put occasionally upon the mouth of the kneed tube F, in order to prevent rain from being blown into the mouth of the wind-gage when it is left out all night or exposed in the time of rain.

The force or momentum of the wind may be ascertained by the assistance of this instrument, by filling the tubes half full of water, and pushing the scale a little up or down, till the 0 of the scale, when the instrument is held up perpendicularly, be on a line with the surface of the water in both legs of the wind-gage. The instrument being thus adjusted, hold it up perpendicularly, and, turning the mouth of the kneed tube towards the wind, observe how much the water is depressed by it in the one leg, and raised in the other. The sum of the two is the height of a column of water which the wind is capable of sustaining at that time; and every body that is opposed to that wind will be pressed upon by a force equal to the weight of a column of water having its base equal to the altitude of a column of water, sustained by the wind in the wind-gage. Hence the force of the wind upon any body where the surface opposed to it is known may be easily found; and a ready comparison may be made betwixt the strength of one gale of wind and that of another.

The force of the wind may be likewise measured with this instrument, by filling it until the water runs out at the hole G. For if we then hold it up to the wind as before, a quantity of water will be blown out; and if both legs of the instrument are of the same bore, the height of the column sustained will be equal to double the column of water in either leg, or the sum of what is wanting in both legs. But if the legs are of unequal bores, neither of these will give the true height of the column of water which the wind sustained. But the true height may be obtained by the following formulæ.

Suppose that after a gale of wind which had blown the water from A to B, fig. 100, forcing it at the same time through the other tube out at E, the surface of the water should be found standing at some level as DG, and it were required to know what was the height of the column EF or AB, which the wind sustained. In order to obtain this, it is only necessary to find the height of the columns DB or GF, which are constantly equal to one another; for either of these, added to one of the equal columns AD, EG, will give the true height of the column of water which the wind sustained. 1. Let the diameters AC, EH, of the tubes, be respectively represented by *cd*; and let $a = AD$ or EG, and $x = DB$ or GF; then it is evident, that the column DB is to the column EG, as c^2x to d^2a. But these colums are equal. Therefore $c^2x = d^2a$; and consequently $x = \frac{d^2a}{c^2}$. But if, at any instant of

time whilst the wind was blowing, it was observed, that when the water stood at E, the top of the tube out of which it is forced, it was depressed in the other to some given level BF, the altitude at which it would have stood in each had it immediately subsided, may be found in the following manner. Let $b = AB$ or EF. Then it is evident that the column DB is equal to the difference of columns EF, GF. But the difference of these columns is as $d^2b - d^2x$; and consequently $x = \frac{d^2b}{c^2 + d^2}$.

For the cases when the wind blows in at the narrow leg of the instrument: Let $AB = EF = b$, EG or $AD = a$, $GF = DB = x$, and the diameters EH, CA, respectively $= d, c$, as before. Then it is evident, that the column AD is to the column GF as ac^2 to d^2x. But these columns are equal; therefore $d^2x = ac^2$; and consequently $x = \frac{ac^2}{d^2}$. It is also evident, that the column AD is equal to the difference of the columns AB, DB; but the difference of these columns is as $bc^2 - c^2x$. Therefore $d^2x = bc^2 - c^2x$. Whence we get $x = \frac{bc^2}{d^2 + c^2}$.

The use of the small tube of communication *a b*, fig. 98. is to check the undulation of the water, so that the height of it may be read off from the scale with ease and certainty. But it is particularly designed to prevent the water from being thrown up to a much greater or less altitude, than the true height of the column which the wind is able at that time to sustain, from its receiving a sudden impulse whilst it is vibrating either in its ascent or descent. As in some cases fresh water in this instrument might be liable to freeze, and thus break the tubes, Dr. Lind recommends a saturated solution of sea-salt to be used instead of it, which does not freeze till Fahrenheit's thermometer falls to 0.

Tide-GAGE, an instrument used for determining the height of the tides by Mr. Bayley, in the course of a voyage towards the south pole, &c. in the Resolution and Adventure, in the years 1772, 1773, 1774, and 1775. This instrument consists of a glass tube, whose internal diameter was 7-10ths of an inch, lashed fast to a 10 foot fir rod, divided into feet, inches, and parts, the rod being fastened to a strong post fixed firm and upright in the water. At the lower end of the tube was an exceedingly small aperture, through which the water was admitted. In consequence of this construction, the surface of the water in the tube was so little affected by the agitation of the sea, that its height was not altered the 10th part of an inch when the swell of the sea was 2 feet; and Mr. Bayley was certain, that with this instrument he could discern the difference of the 10th of an inch in the height of the tide.

GAHNIA, a genus of the monogynia order, in the hexandria class of plants. The calyx is an involucrum with two or five flowers; the corolla is two-valved; the stamina six capillary and very short filaments; the antheræ linear, sharp-pointed at the apex, and as long as the corolla; there is no pericarpium: the seed is single and oblong. There are two species, herbs of New Zealand and Otaheite.

GAIANITES, *gainaitæ*. in church history, a branch of eutychians.

GALBULA, in ornithology, a genus of the order picæ, bill straight, very long, quadrangular, pointed; nostrils oval, at the base of the bill: tongue short, sharp-pointed; thighs downy on the forepart. The viridis inhabits the moist woods of Guinea and Brazil; the size of a lark: it feeds on insects. There are three other species, viz. the grandis, the paradisea and albirostris.

GALANGALS, the name of two roots kept in the shops, a greater and a smaller; of which the smaller is by far most esteemed. See MATERIA MEDICA.

GALANTHUS, the SNOW-DROP, a genus of the monogynia order, in the hexandria class of plants, and in the natural method ranking under the ninth order, spathaceæ. There are three concave petals; and the nectarium consists of three small emarginated petals; the stigma is simple. There is but one species, viz. the nivalis: which is a bulbous rooted flowery perennial, rising but a few inches in height, and adorned at top with small tripetalous flowers of a white colour. There are three varieties, viz. the common single-flowered snow-drop, the semi double snow-drop, and the double snow-drop. They are beautiful little plants, and are much valued on account of their early appearance, often adorning the gardens early in the spring, when scarcely any other flower is to be seen, making a very ornamental appearance especially when disposed in clusters towards the fronts of the borders, &c. The single kind comes first into bloom, then the semi-double, and after that the double. They will succeed any where, and multiply exceedingly by off-sets from the roots.

GALARDIA, a genus of the class and order syngenesia polygamia frustranea. The recept. is chaffy; seed crowned with five-leaved calycle; cal. two-rows of scales, almost equal. There is one species; an annual of Louisiana.

GALAX, a genus of the pentandria monogynia class and order. The cal. is ten-leaved; cor. silver-shaped; caps. one-celled, two-valved, and elastic. There is one species, an herb of Virginia.

GALAXIA, a genus of the monodelphia triandria class and order. The spethe. is one-valved; cor. one-petalled, six-cleft; tube capillary; stigma many parted. There are two species, herbs of the Cape.

GALAXY, in astronomy, the via lactea, or milky way of the heavens: a tract of a whitish colour, and considerable breadth, which runs through a great compass of the heavens, sometimes in a double, but for the greatest part of its course in a single stream; and is composed of a vast number of stars, too minute or too remote from the earth, to be distinguished by the naked eye; but are discovered in all parts of it, in great numbers, by the assistance of the telescope. See ASTRONOMY.

GALBANUM, a gum issuing from the stem of an umbelliferous plant, growing in Persia and many parts of Africa.

It is sometimes met with in the shops in loose granules, called drops or tears, and sometimes in large masses, formed of a number of these blended together; but in these masses some accidental foulness is often mixed with the gum. The single drops usually approach to a round-

ish, oblong, pearlike form. Galbanum is soft like wax, and, when fresh drawn, white; but it afterwards becomes yellowish or reddish: it is of a strong smell, of an acrid and bitterish taste; it is inflammable in the manner of a resin, and soluble in water like a gum. It attenuates and dissolves tough phlegm, and is therefore of service in asthmas and inveterate coughs: it is also of great service in hysteric complaints; it dissipates flatulencies. It is given in pills and electuaries, and is used externally in form of a plaster, applied to the abdomen, against habitual hysteric complaints, and on many other occasions.

GALEASSE, a large low-built vessel, using both sails and oars, and the largest of all the vessels that make use of the latter. It may carry twenty guns, and has a stern capable of lodging a great number of marines. It has three masts, which are never to be lowered or taken down. It has also thirty-two benches of rowers, and to each bench six or seven slaves, who sit under cover. This vessel has latterly been only used by the Venetians.

GALEGA, a genus of the class and order diadelphia decandria. The cal. has tubulate teeth nearly equal; legume with streaks between the seeds. There are 19 species, some of them known by the name of goat's rue.

GALENIA, a genus of the digynia order, in the octandria class of plants, and in the natural method ranking under the 13th order, succulentæ. The calyx is trifid; there is no corolla; the capsule is roundish and dispermous. There are two species, shrubs of the Cape.

GALENIC, or Galenical, in pharmacy, a manner of treating diseases founded on the principles of Galen. The distinction of galenical and chemical, was occasioned by a division of the practitioners of medicine into two sects, which happened on the introduction of chemistry into medicine; then the chemists, arrogating to themselves every kind of merit and ability, stirred up an opposition to their pretensions, founded on the invariable adherence of the other party to the ancient practice. And although this division into two sects of galenists and chemists has long ceased, yet the distinction of medicines which resulted from it is still retained.

Galenical medicines are those which are formed by the easier preparations of herbs, roots, &c. by infusion, decoction, &c. and by combining and multiplying ingredients; while those of chemistry draw their more intimate and remote virtues by means of fire and elaborate preparations, as calcination, digestion, fermentation, &c.

GALENISTS, in church history, a branch of anabaptists, who are said to have adopted several arian opinions concerning the divinity of our Saviour.

GALENA, in mineralogy, sulphuret of lead, is very common, and is found both in masses and crystallized. The primitive form of its crystals is a cube. The most common varieties are the cube, sometimes with its angles wanting, and the octahedron, composed of two four-sided pyramids applied base to base. The summits of these pyramids are sometimes cuneiform, and sometimes their solid angles are wanting.

Its colour is commonly blueish grey like lead, but brighter. Streak blueish grey and metallic. Lustre metallic. Sometimes stains the fingers. Texture foliated. Fragments cubical. Soft; but brittle. Specific gravity 7.22 to 7.587. Effervesces with nitric and muriatic acids. Before the blow-pipe decrepitates, and melts with a sulphureous smell; part sinks into the charcoal. It is composed of from .45 to .83 lead, and from .086 to .16 of sulphur. It generally contains some silver, and sometimes also antimony and zinc.

To this species is to be referred a mineral which occurs but rarely, called

Compact galena. Found in mass; sometimes in specular plates. Texture compact. Fracture even. Softer than common galena. Specific gravity 7.444. Streak lead grey, brighter, and metallic. Feels soft, and stains the fingers. Fragments indeterminate. Found in Derbyshire, and in different parts of Germany and Italy. Often mistaken for plumbago or molybdena. Another species is

Blue lead ore. This ore has hitherto been observed only at Zschopau in Saxony. It occurs rarely in mass, usually crystallized in small six-sided prisms. Colour between indigo blue and lead grey; sometimes inclining to black. Usually striated longitudinally. Internal lustre metallic. Streak brighter. Texture compact. Specific gravity 5.461. Before the blow-pipe melts with a low blue flame and a sulphureous smell, and is easily reduced. It has not been analysed. Its crystals resemble those of phosphat of lead; but its component parts seem to be the same as those of galena. Brochan supposes it a phosphat converted into a galena by some unknown process. A third species is

Black lead ore. This ore is found in Saxony, Poland, Siberia, and in different parts of Britain. It occurs in mass, disseminated and cellular; but more frequently crystallized in six-sided prisms, which are generally truncated and confused. Colour greyish black. Streak greyish black. Brittle. Specific gravity from 5.744 to to 5.77. Before the blow-pipe it decrepitates, melts easily and is reduced.

GALEOPITHECUS. Colugo. A genus of quadrupeds. The generic character is front-teeth in the upper jaw none; in the lower six, short, broad, distant, pectinated; canine-teeth very short, triangular, broad, sharp, serrated; grinders four, truncated, and muricated with conical proturberances; flying-skin surrounding the body, limbs, and tail.

This singular animal, which, from its size and extraordinary conformation, claims a conspicuous place among the productions of nature, has but lately been examined with the degree of exactness necessary for ascertaining clearly its generic characters. It is to Dr. Pallas that we owe the exact knowledge of these particulars, and an accurate description, accompanied by good figures, may be found in the transactions of the Academy of Petersburgh for the year 1780.

Galeopithecus volans, the flying colugo, is a native of the Molucca and Philippine islands, where it is said to frequent woody places, and to feed principally on fruits. It almost constantly resides on trees, and makes use of its membranes in the same manner as the flying squirrel. In descending from the top of a tree, it spreads its membranes, and balances itself to the place it aims at in a gentle manner; but in ascending it uses a leaping pace. It has two young, which are said to adhere to its breasts by the mouth and claws. The whole length of the animal is about three feet: the breadth, when expanded, nearly the same: the tail is slender and about a span long. The

membrane, or expansile skin, by which it is enabled to fly, is continued, on each side, from the neck to the fore feet; thence to the hind feet; and again to the tip of the tail: it is not naked, like the skin of a bat's wing, but covered with fur, in the same manner as the body: the inner or lower side, however, appears membranaceous, and is marked by numerous veins and fibres dispersed through it. The whole upper side of the animal is generally of a deep ash-colour, most so in those which are full-grown, and blacker in the younger or less advanced specimens: the back also, in the full-grown animals, is crossed transversely with blackish lines; towards the edges, is commonly a tinge of yellowish, and the whole under side, both of the body and membrane, is of a yellowish colour. The head is long; the mouth rather small; the tongue, according to Dr. Pallas, fleshy, broad, rounded, attenuated on the edges, and ciliated with papillæ, as in the opossums: it is also slightly beset with papillæ on its surface. There are no fore-teeth in the upper jaw, but in the lower are six, which are short, broad, and pretty deeply pectinated, so as to resemble little combs on their upper part: the canine teeth, or at least those which Dr. Pallas considers as such, are shaped somewhat like the petrifactions known by the name of glossopetræ, being triangular, very broad at their base, very short, sharp-pointed, and serrated; the grinders, or molares, which are generally four, both above and below, are of an abrupt or truncated form, and roughened with conical protuberances. The ears are small, round, membranaceous, and marked internally by numerous semicircular transverse streaks, as in a bat. The legs are clothed with a soft yellow down: there are five toes on each foot, united by a common membrane, and terminating in large, thin, broad, very sharp crooked claws. This animal is said to be called by the Indians caguang, colugo, and gigua. It was first described by Bontius, in his History of Java. He informs us that it is found in Guzarat, in India; that it is a gregarious animal, and flies principally in the evening; and that its body is of the size of a cat, and is covered above with a soft, grey fur, like that of a rabbit; that the head is oblong, the ears small and round, and that it has five strong claws on each foot, by which it holds firmly whatever it seizes, and that it feeds chiefly on fruits. Camelli, in his enumeration of the animals of the Philippine isles, published by Petiver in the Philosophical Transactions, describes it as about the size of a cat, shaped like a monkey, but more slender, and of the length of about three spans from head to tail; but adds, that in some parts it arrives at a far larger size, so as to equal a Chinese umbrella in expanse. He describes the colour on the upper parts as dusky, and elegantly variegated with whitish streaks on the back, running beyond the body over the flying membrane; the face he compares to that of a monkey, and the manner of flight to that of a flying squirrel: Camelli adds, that the young adhere to the teats of the parent by their mouth and claws; but it is remarkable, that in his manuscript on this subject now preserved in the British Museum, he expressly asserts that the female is furnished with two sacs or pouches on her belly, in which she carries her young while sucking.

Linnæus, judging of this animal's place in systematic arrangements, from the figures and descriptions of authors, but not having had an opportunity of examining its generic characters himself, placed it in the genus Lemur, to which he supposed it most allied; but was careful, at the same time to observe, that, as its teeth had not been examined, its real genus was, of course, not determinable. By the count de Buffon it was, with unpardonable negligence, entirely omitted; nor was it till Dr. Pallas's description in the Petersburgh Transactions appeared, that its generic characters were ascertained.

GALILEANS, a sect of the Jews. Their founder was one Judas, a native of Galilee, from which place they derived their name. Their chief, esteeming it an indignity for the Jews to pay tribute to strangers, excited his countrymen against the edict of the emperor Augustus, which had ordered a taxation or enrolment of all the subjects of the Roman empire. They pretended that God alone should be owned as master and lord; and in other respects were of the opinions of the pharisees: but, as they judged it unlawful to pray for infidel princes, they separated themselves from the rest of the Jews, and performed their sacrifices apart.

GALIUM, a genus of the monogynia order, in the tetrandria class of plants, and in the natural method ranking under the 47th order, stellatæ. The corolla is monopetalous and plain; and there are two roundish seeds. There are 48 species, of which the most remarkable are, the verum or yellow lady's bed-straw, and the aperine, clivers or goose-grass. The former has a firm, erect, brown, square, stem; the leaves generally eight in each whorl, linear, pointed, brittle, and often reflex; branches short, generally two from each joint, terminating in spikes of small yellow flowers. It grows commonly in dry ground and on road-sides. The flowers will coagulate boiling milk; and the best Cheshire cheese is said to be prepared with them. The French prescribe them in hysteric and epileptic cases. Boiled in alum-water, they tinge wool yellow. The roots dye a red not inferior to madder; for which purpose they are used in the island of Jura. In the Edinburgh Medical Commentaries we have accounts of some violent scorbutic complaints being cured by the juice of this plant. Sheep and goats eat the plant; horses and swine refuse it; cows are not fond of it. The aperine or clivers has a square, very rough, jointed, very weak stem, two, three, or four feet long, and adhesive: the branches are opposite; the joints hairy at the base. The expressed juice of this plant taken internally, and the bruised leaves applied by way of poultice, are said to have been used with success as a cure for the cancer. The effects are, however, uncertain: the course, it is said, often requires to be continued for nine or ten months.

GALL, in the animal œconomy, the same with bile. See PHYSIOLOGY.

GALL-BLADDER, called vesicula, and cystis fellea, is usually of the shape of a pear, and of the size of a small hen's egg. It is situated in the concave side of the liver, and lies upon the colon, part of which it tinges with its own colour. It is composed of four membranes, or coats: the common coat; a vesicular one; a muscular one, consisting of straight, oblique, and transverse fibres; and a nervous one, of a wrinkled or reticulated surface within, and furnished with an unctuous liquor. See ANATOMY.

The use of the gall-bladder is to collect the bile, first

secreted in the liver, and mixing with its own peculiar produce, to perfect it farther, to retain it together a certain time, and then to expel it.

Gall, in natural history, denotes any protuberance or tumour produced by the puncture of the insects on plants and trees of different kinds. Galls are of various forms and sizes, and no less different with regard to their internal structure. Some have only one cavity, and others a number of small cells communicating with each other. Some of them are as hard as the wood of the tree they grow on, whilst others are soft and spongy; the first being termed gall-nuts, and the latter berry-galls, or apple-galls.

The general history of galls is this: an insect of the fly-kind (See Cynips), is instructed by nature to take care for the safety of her young, by lodging her eggs in a woody substance, where they will be defended from all injuries: she for this purpose wounds the branches or leaves of a tree, and the lacerated vessels, discharging their contents, soon form tumours about the holes thus made. The hole in each of these tumours, through which the fly has made its way, may for the most part be found; and when it is not, the maggot inhabitant or its remains, are sure to be found within, on breaking the gall. It is to be observed, however, that in those galls which contain several cells, there may be insects found in some of them, though there is a hole by which the inhabitant of another cell has escaped.

Oak-galls put, in a very small quantity, into a solution of vitriol in water, though but a very weak one, give it a purple or vitriol colour; which, as it grows stronger, becomes black; and on this property depends the art of making our writing-ink, as also a great deal of those of dying and dressing leather, and other manufactures. See Ink, &c.

Gall-stones. See Concretions.

GALLATS, in chemistry: whether gallic acid is capable of forming crystallizable salts with the different bases, is still a problem which chemists have not resolved.

1. When the alkalies are dropt into a solution of gallic acid in water, or into a solution containing gallic acid, it assumes a green colour. This change is considered by Proust as the most decisive test of the presence of gallic acid. The same change of colour takes place when gallic acid is poured into barytes water, strontian water, or lime water, and at the same time a powder of a greenish brown colour precipitates. The green liquid which remains contains only gallic acid combined with the earth employed in the experiment. But if we attempt to evaporate it to dryness, the green colour disappears, and the acid is almost completely decomposed.

2. When magnesia is boiled with the infusion of nut-galls, the liquid becomes almost limpid, and assumes the same green colour as the former mixtures. From the experiments of Mr. Davy, it appears, that in this case all the extract of tan is separated from the infusion, together with a portion of the gallic acid; and that the liquid holds in solution nothing but a combination of that acid and magnesia. But in this case also the acid is decomposed, and the green colour disappears when we attempt to obtain the composition in a dry state.

3. When a small portion of alum is mixed with the infusion of nut-galls, it separates the whole of the tan and extract, and leaves the liquid limpid and of a very pale yellowish green colour. This liquid, by spontaneous evaporation, yields small transparent prismatic crystals, which, according to Mr. Davy, are supergallats of allumina. They afford the only instance of a gallat capable of existing in the state of crystals. The quantity of allumina is very small; two small to disguise the properties of the acid.

GALLEON, in naval affairs, a sort of ships employed by Spain in the commerce of the West-Indies. The Spaniards send annually two fleets; the one for Mexico, which they call the flota; and the other for Peru, which they call the galleons. By a general regulation made in Spain, it has been established, that there should be twelve men of war, and five tenders annually fitted out for the armada or galleons; eight ships of 600 tons burden each, and three tenders, one of 100 tons, for the island of Margarita, and two of 80 each, to follow the armada: for the New Spain fleet, two ships of 600 tons each, and two tenders of 80 each; and for the Honduras fleet, two ships of 500 tons each: and in case no fleet happened to sail any year, three galleons and a tender should be sent to New Spain for the plate. They are appointed to sail from Cadiz in January, that they may arrive at Porto Bello about the middle of April; where, the fair being over, they may take on board the plate, and be at Havannah with it about the middle of June; where they are joined by the flota, that they may return to Spain with the greater safety.

GALLERY, in fortification, a covered walk, across the ditch of a town, made of strong beams, covered over head with planks, and loaded with earth: sometimes it is covered with raw hides to defend it from the artificial fires of the besieged. See Fortification.

Gallery *of a mine*, is a narrow passage, or branch of a mine carried on under-ground to a work designed to be blown up. Both the besiegers and the besieged also, carry on galleries in search of each others mines, and these sometimes meet and destroy each other.

Gallery, in a ship, that beautiful frame, which is made in the form of a balcony, at the stern of a ship without board; into which there is a passage out of the admiral's or captain's cabin, and is for the ornament of the ship.

GALLEY, in naval affairs, a low-built vessel using both sails and oars, and commonly carrying only a main-mast and foremast, to be struck or lowered at pleasure.

GALLIAMBIC verse, in ancient poetry, a verse consisting of six feet, viz. an anapest or a spondee; an iambus, or an anapest, or a tribrach; an iambus; a dactyl; an anapest.

GALLIC acid, in chemistry, is obtained from the nut-gall which grows on some species of oak. In an infusion of galls made with cold water, a sediment is formed which on examination is found to have a crystalline form and an acid taste. By letting an infusion of galls remain a long time exposed to the air, and removing now and then the mouldy skin which formed on its surface, a large quantity of this sediment was obtained; which being edulcorated with cold water, redissolved in hot water, filtrated and evaporated very slowly, yielded an acid salt in crystals as fine as sand.

Mr. Davy has lately pointed out another method which

yields gallic acid in a state of considerable purity. Boil for some time a mixture of carbonat of barytes and infusion of nut-galls. A blueish green liquid is obtained, which consists of a solution of gallic acid and barytes. Filter and saturate with diluted sulphuric acid. Sulphat of barytes is deposited in the state of an insoluble powder, and a colourless solution of gallic acid remains behind.

Gallic acid, when pure, is in the form of transparent plates or octahedrons. Its taste is acid, and somewhat astringent; and when heated it has a peculiar and rather unpleasant aromatic odour.

It is soluble in one and a half parts of boiling water, and in 12 parts of cold water. When this solution is heated, the acid undergoes a very speedy decomposition. Alcohol dissolves one-fourth of its weight of this acid at the temperature of the atmosphere. When boiling hot, it dissolves a quantity equal to its own weight. It is insoluble in ether. When exposed to the action of heat, it is sublimed without alteration: but a strong heat decomposes it in part, and converts it into an acid water, carbureted hydrogen gas, carbonic acid gas, oil, and charcoal. When distilled, a quantity of oxygen gas is disengaged, an acid liquor is found in the receiver, with some gallic acid not decomposed, and there remains in the retort a quantity of charcoal. If what has passed into the receiver is again distilled, more oxygen gas is obtained, some gallic acid still sublimes, and a quantity of charcoal remains in the retort. By repeated distillations the whole of the acid may be decomposed. This decomposition may be more easily accomplished by distilling repeatedly a solution of gallic acid in water. The products are oxygen gas, charcoal, and an acid liquor.

From these experiments it was concluded, that gallic acid is composed of oxygen, and a much larger proportion of carbon than enters into the composition of carbonic acid. But this conclusion is not warranted by the analysis: for the quantity of oxygen gas and carbon obtained was not equal to that of the gallic acid decomposed; and in the acid liquor which came over, there evidently existed a quantity of water, which doubtless was formed during the distillation. Scheele, by treating gallic acid with nitric acid in the usual manner, converted it into oxalic acid. Now it is certain that oxalic acid contains hydrogen as well as carbon. It cannot be doubted, then, that gallic acid is composed of oxygen, hydrogen, and carbon, in proportions not yet ascertained. But Mr. Deyeux has proved, that the quantity of carbon is very great, compared with that of the hydrogen.

Gallic acid is not altered by exposure to the air. Neither oxygen gas, the simple combustibles, nor azote, seem to have any particular action on it. Its action on the metals has not been examined. It combines with alkalies, earths, and metallic oxides, and forms compounds called gallats, most of which are still but very imperfectly known.

As the greater number of its combinations with metallic oxides are insoluble, it for the most part occasions a precipitate when poured into a solution containing a metal; and this precipitate differs in colour, according to the metal which occasions it. Hence this acid, or at least the infusion of nut-galls, is very much used by chemists to detect the presence of metals when held in solution. The formation of a precipitate, with infusion of nut-galls, is even considered as a property almost peculiar to metallic oxides. It ought to be remarked, however, that all the metals are by no means precipitated from their solutions by gallic acid. The following must be excepted:

1. Platinum,	4. Cobalt,
2. Tin,	5. Manganese,
3. Zinc,	6. Arsenic.

The following Table exhibits a view of the colours of the precipitates of different metals by means of this acid:

Gold	Brown
Silver	Brown
Mercury	Orange yellow
Copper	Brown
Iron	Black
Lead	White
Nickel	Grey
Bismuth	Orange
Antimony	White
Tellurium	Yellow
Uranium	Chocolate
Titanium	Reddish brown
Chromium	Brown
Columbium	Orange

Molybdic acid acquires a dark yellow colour, but does not precipitate.

But the colour of these metallic precipitates varies considerably according to the state of oxydizement, and the acid with which they are composed. These differences are especially remarkable in the solutions of mercury and copper.

Gallic acid produces no change in the solutions of alkaline salts: but when dropt into barytes water, strontian water, or lime water, it gives them a blueish-red colour, and occasions a flaky precipitate, composed of the acid combined with the earths.

Gallic acid occasions a precipitate when poured into solutions of glucina, yttria, and zirconia in acids. This property distinguishes these three bodies from all the other earths, none of which are precipitated from their solutions in acids by gallic acid.

The affinities of gallic acid are still undetermined. Mr. Richter has shown, that it is not capable of taking iron from sulphuric acid, as has been hitherto supposed, unless it is assisted by the action of some other body which has an affinity for sulphuric acid. He has endeavoured to show, too, contrary to the experiments of Proust, that it strikes a black with all the oxides of iron; but his proofs are by no means sufficient to decide that point.

GALLINÆ, in ornithology, the fifth order of birds: the upper mandible is channelled, extending with a margin above the lower, and a little bowed; the nostrils are covered with a cartilaginous membrane; they live upon grain, dust themselves, make an artless nest and lay many eggs. Under this order are comprehended the peacock, pheasant, turkey, the common dunghill cock, partridge, grous, dodo, curissoa, &c.

GALLIUM, *ladies bed-straw*. See GALIUM.

GALLON, a measure of capacity both for dry and liquid articles, containing four quarts; but these quarts, and consequently the gallon itself, are different, accord-

ing to the quality of the thing measured; for instance, the wine gallon contains 231 cubic inches, and holds eight pounds five ounces and two-thirds avoirdupois, of pure water: the beer and ale gallon contains 282 solid inches, and holds ten pounds three ounces and a quarter avoirdupois, of water: and the gallon for corn, meal, &c. two hundred and sixty-eight cubic inches and four-fifths, and holds nine pounds eleven ounces and a half of pure water.

GALLOON, in commerce, a narrow thick kind of ferret or lace, used to edge or border clothes, sometimes made of wool, and at others of gold or silver.

GALOPINA, a genus of the tetandria digynia class and order. Cal. none; cor. four cleft; seeds two, naked. A plant of the Cape.

GALVANISM, a term used to denote the influence of metals by mere external contact with the animal body. In the year 1791, a very remarkable discovery made by Dr. Galvani of Bologna was announced to the scientific world in a publication entitled, Aloysii Galvani de Viribus Electricitatis in motu musculari Commentarius. Bononiæ 1791.

The discoveries of Galvani were made principally with dead frogs. He in the first place discovered that a frog dead and skinned, is capable of having its muscles brought into action by means of electricity, even in exceedingly small quantities.

Secondly, that independant of any apparent electricity, the same motions may be produced in the dead animal, or even in a detached limb, merely by making a communication between the nerves and the muscles, with substances that are conductors of electricity. If the circuit of communication consists of non-conductors of electricity, as glass, sealing-wax, and the like, no motion will take place. Similar experiments were also successfully instituted upon other animals; and as the power seemed to be inherent in the animal parts, those experiments, or the power which produces the motion of the muscles in those experiments, were denominated animal electricity. But it being now fully ascertained, that by the mere contact of metallic and other conducting substances, some electricity is generated, it is evident that the muscular motions in the above-mentioned experiments are produced by that electricity; hence we have confined the name of animal electricity to denote the power of the fishes which give the shock, &c. as described in a preceding article. (See Electricity.) And, at least for the present, we shall examine the electricity which is produced by the contact, or by the action, of metallic and other conducting substances upon each other, under the title of galvanism; though in truth Galvani's discoveries go no farther than what relates to certain effects of the contact of animal parts principally with metallic. We shall briefly describe the several facts which relate to the above-mentioned sort of muscular motion, and shall then proceed to those which refer to the wonderful effects of the mere contact or action of one conducting substance upon another, amongst which the metallic are the most conspicuous.

The action of electricity on a frog, recently dead and skinned, (and indeed on other animals more or less) occasions a tremulous motion of the muscles, and generally an extension of the limbs.

Dr. Galvani used to skin the legs of a frog recently dead, and to leave them attached to a small part of the spine, but separated from the rest of the body. Any other limb may be prepared in a similar manner: viz. the limb is deprived of its integuments, and the nerve which belongs to it is partly laid bare.

If the limbs thus prepared, for instance the legs of a frog, are situated so that a little electricity may pass through them, be it by the immediate contact of an electrified body, or by the action of electric atmospheres (as when the preparation is placed within a certain distance of an electrical machine, and a spark is taken from the prime conductor); the prepared legs will be instantly affected with a kind of spasmodic contraction, sometimes so strong as to jump a considerable way.

When the electricity is caused to pass through the prepared frog by the immediate contact of the electrified body, a much smaller quantity of it is sufficient to occasion the movements, than when it is made to pass from one conductor to another, at a certain distance from the prepared animal.

The movements are much stronger when the electricity is caused to pass through a nerve to the muscle or muscles, than through any other part.

The sensibility of the prepared animal is greatest at first, but it diminishes by degrees till it vanishes entirely. Animals with cold blood, and especially frogs, retain that sensibility for several hours, sometimes even for a day or two. With other animals the sensibility does not last long after death, and sometimes not above a few minutes.

The like movements may be produced in the prepared animal without the aid of any apparent electricity. In an animal recently dead, detach one end of a nerve from the surrounding parts, taking care to cut it not too near its insertion into the muscle; remove the integuments from over the muscles which depend on that nerve; take a piece of metal, as a wire, and touch the nerve with one extremity of it, and the muscles with its other extremity; on doing which you will find that the prepared limbs move in the same manner as when some electricity is passed through them. This, however, is not the most effectual way of forming the communication: yet it will generally succeed, and the experiment will answer whether the preparation is laid upon conductors or upon electrics.

If the communication between the nerve and the muscle is formed by the interposition of non-conductors of electricity, such as glass, sealing-wax, &c. then no movements will take place.

When the application of the metal or metals is continued upon the parts, the contractions will cease after a certain time, and on removing the metal, seldom, if ever, any contraction is observed.

The conducting communication between the muscle and the nerve may consist of one or more pieces, and of the same or, much better, of different bodies connected together, as metals, water, a number of persons, and even wood. But it must be observed, that the various bodies, which form this circuit, must be placed in full and perfect contact with each other, which is done by pressure, or by the interposition of water, &c. The less perfect conductors will answer only at first, when the

prepared animal is vigorous; but when the power begins to diminish, then the more perfect conductors only will answer, and even these will produce various effects.

The most effectual way of producing those movements in prepared animal parts is by the application of two metals, of which silver and zinc seem upon the whole to be best, though silver and tin, or copper and zinc, and other combinations, are not much inferior. If part of the nerve proceeding from a prepared limb is wrapped up in a bit of tin foil, or only laid upon zinc, and a piece of silver laid with one end upon the bare muscle, and with the other upon the above-mentioned tin or zinc, the motion of the prepared limb will be very vigorous. The two metals may be placed not in contact with the preparation, but in any other part of the circuit, which may be completed by means of other conductors, as water, &c.

The best preparation for this experiment is made in the following manner:

Separate with a pair of scissars the head and upper extremities of a frog from the rest of the body. Open the integuments and muscles of the abdomen, and remove the entrails, by which means you will lay bare the crural nerves. Then pass one blade of the scissars under the nerve, and cut off the spine with the flesh close to the thighs, by which means the legs will remain attached to the spine by the nerves alone. This done, leave a small bit only of the spine attached to the crural nerves, and cut off all the rest. Thus you will have the lower limbs G, H, (fig. 1, Plate LXI. Galvanism) of the frog adhering to the bit of spine A B, by means of the crural nerves C, D. These legs must be flayed in order to lay bare the muscles; and a bit of tin foil should be wrapped round the spine A B. With this preparation the experiment may be performed in various ways, but the two which follow are the best.

Hold the preparation by the extremity of one leg, the other leg hanging down, with the armed bundle of nerves and spine lying upon it. In this situation interpose a piece of silver, as a half-crown, between the lower thigh and the nerves, so that it may touch the former with one surface, and the metallic coating of the latter with the other surface, or with its edge; and you will find that the hanging leg will vibrate very powerfully, sometimes so far as to strike against the hand of the operator, which holds the other leg.

Otherwise, place two wine-glasses, both full of water, contiguous to each other, but not actually touching. Put the thighs and legs of the preparation in the water of one glass, and laying the nerves over the edges of the two glasses, let the bit of spine with its armour (viz. tin foil) touch the water of the other glass. Things being thus prepared, if you form the communication between the waters of the two glasses, by means of silver, or put the fingers of one hand into the water of the glass that contains the legs, and holding a piece of silver in the other, you touch the coating of the nerves with it, you will find that the prepared legs move so powerfully as sometimes to jump fairly out of the glass.

Fig. 2 represents a prepared frog suspended on a metallic wire, and parallel to the animal, a metallic chain. When the receiver x is exhausted, on pushing down the rod so that the nerve of the frog and the chain may touch the metallic plate z at the bottom, the frog is convulsed as in the open air.

By the application of armours of different metallic substances, and forming a communication between them, the motions may be excited even in an entire living frog, as also in some other living animals, particularly eels and flounders. The living frog is placed upon a piece of zinc, with a slip of tin foil pasted upon its back. This done, whenever the communication is formed between that zinc and the tin foil, especially if silver is used, the spasmodic convulsions are excited, not only in the muscles which touch the metallic substances, but likewise in the neighbouring muscles. This experiment may be performed entirely under water.

Fig. 3 represents a living frog placed in an exhausted receiver, the animal being tied to a plate of silver by a silken string, and having a piece of tin foil on its back. As often as the circuit is completed, the convulsions ensue.

The experiment may be performed with a flounder in a similar easy and harmless manner. Take a living flounder; wipe it pretty dry, and lay it flat on a pewter plate, or upon a sheet of tin foil; and place a piece of silver, as a shilling, a crown piece, &c. upon the fish. Then, by means of a piece of metal, complete the communication between the pewter plate or tin foil and the silver piece: on doing which the animal will give evident tokens of being affected.

It seems that such movements may be excited by the contact of metallic substances in all the animals; at least they have succeeded, but in different degrees, in a great variety of animals from the ox to the fly.

Fig. 4 shows the method of producing convulsions in cold-blooded animals, by the influence of warm-blooded animals. The right hand of the experimentalist is placed in the ear, previously moistened with salt and water, of an ox's head, while in the other hand a prepared frog is suspended by the foot, and the sciatic nerves brought into contact with the ox's tongue. Convulsions are immediately produced in the muscles of the frog.

The human body, whilst undergoing certain chirurgical operations, or its amputated limbs, have been convulsed by the application of metals. But the living animal body may be rendered sensible of the action of metallic application in an harmless way, and both the senses of taste and sight may be affected by it, but in different degrees according to the various constitutions of individuals.

Let a man lay a piece of metal, as zinc, upon his tongue, and a piece of some other metal, as silver, under the tongue; on forming the communication between those two metals, either by bringing their outer edges in contact, or by the interposition of some other piece of metal, he will perceive a peculiar sensation, a kind of irritation, accompanied with a sort of cool and subacid taste, not exactly like, and yet not much different from, that which is produced by artificial electricity. The sensation seems to be more distinct when the metals are of the usual temperature of the tongue. The silver or gold may be applied to any other part of the mouth, to the nostrils, to the ear, or to other sensible parts of the body, whilst the zinc is applied to the tongue; and on making the communication between the two metals, the taste will be perceived upon

the tongue. The effect is rather more remarkable when the zinc touches the tongue in a small part, and the silver in a great portion of its surface, than vice versa. Instead of the tongue, the two metals may also be placed in contact with the roof of the mouth, as far back as possible; and on completing the communication, the taste or irritation will be perceived.

Different persons are variously affected by this application of metals; with some the sensation or taste is so slight as to be hardly perceived, whilst with others it is very strong and even disagreeable. Some persons feel merely a pungency, and not properly a taste.

In order to affect the sense of sight by means of metals, let a man in a dark place put a slip of tin foil upon the bulb of one of his eyes, and let him put a piece of silver, as a spoon or the like, in his mouth. On completing the communication between the spoon and the tin foil, a faint flash of white light will appear before his eyes. This experiment may be performed in a more convenient manner, by placing a piece of zinc between the upper lip and the gums, as high up as possible, and a silver piece of money upon the tongue; or else by putting a piece of silver high up in one of the nostrils, and a piece of zinc in contact with the upper part of the tongue; for in either case the flash of light will appear whenever the two metals are made to communicate, either by the immediate contact of their edges, or by the interposition of other good conductors.

By continuing the contact of the two metals, the appearance of light is not continued, it being only visible at the moment of making the contact, and sometimes, though rarely, at the instant of separation: it may therefore be repeated at pleasure, by disjoining, and again connecting, the two metals. When the eyes are in a state of inflammation, the appearance of light is much stronger.

When the science was advanced no farther than the knowledge of the above-mentioned facts, it was doubtful whether the convulsions of prepared animal limbs, and the sensations which are produced by the application of metallic substances, were owing to some electrical property peculiar to the animal parts, which might perhaps be conducted through the metals from one part to the other; or to a small quantity of electricity, which might be supplied by the metals themselves. The latter supposition however was soon verified by the result of various experiments, which prove in the most convincing manner that electricity is produced by the mere contact, not only of metallic substances, but likewise of other bodies.

The electricity thus produced by the mere contact of bodies is so very small as not to be perceived without great care, and without using some of those artifices for discovering small quantities of electricity, which have been mentioned above. But the discoveries of the ingenious Mr. Volta have shown a method of increasing that electricity to a most extraordinary degree. We shall now proceed to state those facts in as compendious a manner as the nature of the subject will admit of.

The action of metallic substances upon the organs of living, or of recently dead animals, has been fully manifested by the above-mentioned discoveries of Galvani and others; but, previously to these discoveries, a variety of facts, frequently asserted, imperfectly known, and often disbelieved, indicated a peculiar action arising from a combination of different metallic bodies in certain cases.

It had been long asserted, that when porter (and some other liquors also) is drunk out of a pewter pot, it has a taste different from what it has when drunk out of glass or earthenware.

It has been observed, that pure mercury retains its metallic splendour during a long time; but its amalgam with any other metal is soon tarnished or oxidated.

The Etruscan inscriptions, engraved upon pure lead, are preserved to this day; whereas some medals of lead and tin, of no great antiquity, are much corroded. Works of metal, whose parts are soldered together by the interposition of other metals, soon tarnish about the places where the different metals are joined.

When the copper sheeting of ships is fastened on by means of iron nails, those nails, but particularly the copper, are readily corroded about the place of contact.

It had been observed that a piece of zinc might be kept in water for a considerable time, with hardly oxidating at all; but that the oxidation would soon take place if a piece of silver happened to touch the zinc, whilst standing in water.

Since Galvani's discoveries, the action arising from the combination of three conductors has been examined with great care, and with considerable success, especially by Mr. Volta, who lately discovered that the slight effect of such a combination may be increased to a prodigious degree by repeating the combination; for instance, if a combination of silver, zinc, and water, produce a certain effect, a second combination (viz. another piece of silver, another piece of zinc, and another quantity of water) added to the first, will increase the effect; the addition of a third combination will increase the effect still more, and so on.

Previously to the description of the construction of the very remarkable effects of those repeated combinations, which are now generally called galvanic batteries, it will be necessary to state the principal laws, which have been pretty well ascertained with respect to the simple combinations.

1. The conductors of electricity, which, strictly speaking, do almost all differ from each other in conducting power, are nevertheless divided into two principal classes. Those of the first class, otherwise called dry and perfect conductors, are the metallic substances and charcoal. Those of the second class, or the imperfect conductors, are water and other oxidating fluids, as also the substances which contain those fluids. But as the substances of the second class differ in conducting power much more than those of the first class, so they may be subdivided into species.

Mr. Volta arranges those substances in the following order, commencing with the least active; observing, however, that this order is subject to a considerable deviation, especially with respect to the latter species, and according as they are combined with certain bodies of the first class.

"1. Pure water; (it may be observed, that water holding in solution common air, and especially oxygen gas, is much more active than water deprived of air by boiling or otherwise.) 2. Water mixed with clay or chalk; 3. A solution of sugar; 4. Alcohol; 5. Milk; 6. Mucilagi-

nous fluids; 7. Animal gelatinous fluids; 8. Wine; 9. Vinegar and other vegetable juices and acids; 10. Saliva; 11. Mucus from the nose; 12. Blood; 13. Brains; 14. Solution of salt; 15. Soap suds; 16. Chalk-water; 17. Concentrated mineral acids; 18. Strong alkaline leys; 19. Alkaline fluids; 20. Livers of sulphur."

2. The simplest combinations capable of producing galvanic effects, (viz. to convulse the prepared limbs of a frog, or to excite the taste upon the tongue, &c.) must consist of three different conductors; for two conductors only will not produce any sensible effect. If the three conductors are all of the first class, or all of the second, then the effect is seldom sensible. In this case such conductors of the second class as differ more from each other, are more likely to produce a sensible effect than those of the first class. But a proper active simple combination must consist of three different bodies; viz. of one conductor of one class, and two different conductors of the other class. Thus (denoting the bodies of the first class by means of large capital letters, and those of the second class by small letters) the combinations of fig. 5 and 6, are active; but those of fig. 7, 8, 9, 10, and 11, are not active; because that of fig. 7, 8, or 9, consists of two bodies only, and that of fig. 10 or 11, consists of three bodies, of which two are of the same sort, and of course act as a single body.

When two of the three bodies are of the first class, and one is of the second, the combination is said to be of the first order; otherwise it is said to be of the second order.

In a single active galvanic combination, or, as it is commonly called, in a simple galvanic circle, the two bodies of one class must touch each other in one or more points, at the same time that they are connected together at other points by the body of the other class. Thus, when a prepared frog is convulsed by the contact of the same piece of metal in two different places; then the fluids of those parts, which must be somewhat different from each other, are the two conductors of the second class, and the metal is the third body, or the conductor of the first class. If two metals are used, then the fluids of the prepared animal, differing but little from each other, may be considered as one body of the second class. Thus also, when a person drinks out of a pewter mug, the saliva or moisture of his under lip is one fluid or one conductor of the second class, the liquor in the mug is the other, and the metal is the third body, or conductor of the first class.

3. It seems to be indispensably requisite, that in a simple galvanic circle, the conductor or conductors of one class should have some chemical action upon the other conductor or conductors; without which circumstance the combination of three bodies will have either no galvanic action at all, or a very slight one. Farther, the galvanic action seems to be proportionate to the degree of chemical agency; which seems to show that such chemical action is the primary cause of the electric phenomena.

The most active galvanic circles of the first order, are when two solids of different degrees of oxidability are combined with a fluid capable of oxidating at least one of the solids. Thus gold, silver, and water, do not form an active galvanic circle; but the circle will become active if a little nitric acid, or any fluid decomposable by silver, is mixed with the water.

A combination of zinc, silver, and water, forms an active galvanic circle; and the water is found to oxidate the zinc, provided the water holds some atmospheric air, as it commonly does. and especially if it contains oxygen gas. But zinc, silver, and water containing a little nitric acid, form a more powerful galvanic circle, the fluid being capable of acting both upon the zinc and upon the silver.

The most powerful galvanic combinations of the sesecond order, are when two conductors of the second class have different chemical actions on the conductors of the first class, at the same time that they have an action upon each other. Thus copper, or silver, or lead, with a solution of an alkaline sulphuret, and diluted nitrous acid, forms a very active galvanic circle.

The present state of knowledge relative to this subject, does not enable us actually to determine the particular powers of all sorts of galvanic combinations; the following lists, however, contain an useful arrangement of the best combinations, disposed in the order of their powers, and commencing with the most powerful.

Table of galvanic circles of the first order, viz. which consist of two conductors of the first class, and one of the second.

Zinc, with gold, or charcoal, or silver, or copper, or tin, or iron, or mercury; and water containing a small quantity of any of the mineral acids.

Iron, with gold, or charcoal, or silver, or copper, or tin, and a weak solution of any of the mineral acids, as above.

Tin, with gold, or silver, or charcoal, and a weak solution of any of the mineral acids, as above.

Lead, with gold, or silver, and a weak acid solution, as above.

Any of the above metallic combinations, and common water, viz. water containing atmospheric air, or especially water containing oxygen air.

Copper, with gold, or silver, and a solution of nitrate of silver and mercury; or the nitric acid; or the acetous acid.

Silver, with gold, and the nitric acid.

Table of galvanic circles of the second order, viz. which consist of one conductor of the first class, and two of the second.

Charcoal, or Copper, or Silver, or Lead, or Tin, or Iron, or Zinc,	with water, or with a solution of any hydrogenated alkaline sulphurets, capable of acting on the first three metals only;	and a solution of nitrous acid, or oxygenated muriatic acid, &c. capable of acting upon all the metals.

The action of a simple galvanic circle seems to be in some measure dependant upon the quantity of surface of contact between the acting bodies. A higher temperature, within certain limits, renders the activity of the circle greater than a lower temperature.

The activity of a galvanic circle is not altered by the interposition of such conductors as have no action upon the adjoining conductors of the circle. Thus, if a circle consists of zinc, gold, and water; and if you interpose a piece of iron, or of silver, or both, between the zinc and

the gold; the activity of the circle will not be altered. Hence it appears that the action of a galvanic circle may be conveyed through extraneous conductors to a considerable distance; but it must be observed, that the activity is weakened by the great length of the conductors, especially if they are of an imperfect nature.

4. When the three bodies which form a galvanic circle of the first order are laid one upon the other, but the lower and the upper one do not touch each other; then these two extremes are in opposite electric states, viz. the extremity which is next to that metallic surface that touches the body of the second class, is positive, and the opposite extremity is negative. Thus let copper, zinc, and moistened leather, be laid one upon the other, as in fig. 12, and the upper end W, viz. the wetted leather, will be found possessed of positive electricity; whilst the lower end C, or the copper, will be found negative.

5. The galvanic effects may be increased to almost any degree, by connecting several of the above-mentioned active combinations, or by a repetition of the same simple galvanic combination (the most active simple combinations forming the most powerful batteries, and vice versa) provided the simple combinations are disposed so as not to contract each other.

Those batteries are said to be of the first or of the second order, according as the simple combinations, of which they consist, are of the first or of the second order. Thus, if a piece of zinc is laid upon a piece of copper, and a piece of moistened card upon the zinc; then a similar arrangement of three other such pieces laid upon them, and a third arrangement upon this, &c. all in the same order; the whole will form a battery of the first order. But if the arrangement is made by connecting a piece of copper with a piece of cloth moistened with water; the latter with a piece of cloth moistened with a solution of sulphuret of potass, and this again with another piece of copper, &c. the whole will form a battery of the second order.

Mr. Davy distinguishes the batteries of the second order into the following three classes:

1. The most feeble is composed, whenever single metallic plates, or arcs, are arranged in such a manner, that two of their surfaces, or ends opposite to each other, are in contact with different fluids, one capable and the other incapable of oxidating the metal. And regular series of such combinations are formed.

2. When the single combinations or elements of the series consist each of a single plate or arc of a metallic substance capable of acting upon sulphureted hydrogen, or upon sulphuret dissolved in water, accompanied with portions of a solution of sulphurets of potass on one side, and water on the other.

3. The most powerful class is formed when metallic substances oxidable in acids, and capable of acting on solutions of sulphurets, are connected, as plates, with oxidating fluids and solutions of sulphuret of potass, in such a maner that the opposite sides of every plate may be undergoing different chemical changes, the mode of alternation being regular.

The above-mentioned restriction, viz. that the parts of a battery must not counteract each other, will be easily understood by considering that every simple, but interrupted galvanic combination, has a positive and a negative end; or that in every complete galvanic circle, the electric fluid circulates in one way only. Thus, if two simple combinations are disposed as in fig. 14, this arrangement will not have any galvanic power, because the actions of the two simple combinations, or the two currents of electricity, are opposed to each other; the two positive ends being called *p*. and the two negative ends *n*. But if those fixed bodies are disposed as in fig. 15, then the combination will be very active; because, according to the hypothesis, the direction of the electric fluid in each simple arrangement tends the same way, and probably the one accelerates the other.

What has been said above of the arrangement of two simple galvanic combinations, must be likewise understood to hold good with respect to the connection of any number of the same; viz. that they must not counteract each other; or, if a certain number of them counteract each other, then the remaining only form the active part of the battery. For instance, if a battery consists of 40 simple combinations, and if 12 of them are placed in a direction contrary to the others; then these 12 will counteract 12 others, and of course the whole battery will have no more power than if it consisted of 16 simple combinations properly disposed.

This points out a method of comparing the powers of two batteries; for if those batteries are connected in an inverted order, viz. the positive end of one to touch the negative end of the other; then, on connecting the two other extremities, or on applying them to proper instruments, the whole power will be annihilated, if the separate batteries had equal power; otherwise the power of the whole will be the excess of the power of the most powerful battery above that of the weakest; and the direction, viz. its being positive or negative, will show to which battery it belongs. It must be observed, with respect to the inactive arrangement of fig. 14, that if one of the separate bodies Z, is removed, then the remaining five bodies will form an active combination; for in that case, W, W, become one body, and S, S, likewise act as one body.

It is almost superfluous to observe, that (as has been said with respect to simple circles) in a galvanic battery the interposition of conductors that have no particular action, or of the conductors of the same class as the adjoining bodies, does not alter the effect of the battery.

Thus far we have stated the general laws, which have been pretty well ascertained with respect to galvanic combinations. We shall now proceed to describe the practical construction, and the effects of those combinations, especially of the compound arrangements or batteries.

The simplicity of single galvanic circles is so great, that nothing more need be said with respect to their construction; for when the three bodies are selected, the operator needs only take care that their contact is perfect.

Galvanic batteries have been constructed of various shapes, and they may be endlessly diversified. But the most useful forms are represented by figs. 16, 17, and 19. Those of figs. 16 and 17 are more easily constructed; that of fig. 16, however, is the most commodious.

The battery, fig. 16, consists of several glasses, or china cups, full of water, or of water containing salt, &c.; and two plates unconnected with each other, viz. a

plate of zinc and a plate of silver, are plunged in the fluid of each cup, excepting the first and last cups; but each of those plates must have a sort of tail or prolongation, by which they are so connected that the silver plate of one cup communicates with the zinc plate of the next, and so on.

The battery, fig. 17, consists of pieces of silver, about as big as half-crowns, pieces of zinc, of an equal size to those of silver, and pieces of card, or cloth, or leather, or other bibulous substance, a little smaller in diameter than the metallic pieces, and soaked in water or in other proper fluid.

Those pieces are disposed in the order of silver, zinc, and wet cloth, &c. as indicated by the letters S, Z, W. The pieces of card, or cloth, must be well soaked in the fluid; but before they are applied, they should be squeezed, in order that the superfluous fluid may not run down the outside of the pile, or insinuate itself between the contiguous pieces of silver and zinc. Those pieces, especially if soaked in plain water, lose their moisture pretty soon, so that they can hardly serve longer than for a day or two; after which time the pile must be decomposed, the metallic pieces cleaned, those of cloth or card soaked again, and the whole arranged as before.

The three rods R, R, R, are of glass or of baked wood; and the piece of wood, O, slides freely up or down the rods. This serves to prevent the falling of the pieces.

When such battery is to be very powerful, viz. is to consist of numerous pieces, the best way is to form two or three or more piles, and to join them by pieces of metal, as *c c* in fig. 18, where two piles are joined together, so that *a* is the negative extremity, and *b* is the other or positive extremity of the whole arrangement, or of the two piles considered as one.

The battery, fig. 19, consists of a strong oblong vessel of baked wood, about three inches deep and about as much broad. In the sides of this vessel grooves are made opposite to each other, and about one-eighth of an inch in depth. In each pair of opposite grooves a double metallic plate, viz. a plate of zinc and a plate of silver soldered together at their edges, are cemented; by which means the wooden vessel is divided into several partitions, or cells, about half an inch broad, as is sufficiently indicated by the figure. The cementation of the metallic pieces into the sides and the bottom of the wooden vessel, must be so accurate as not to permit the passage of any fluid from one cell into the next. The cement proper for this purpose is made by melting together 5 parts of resin, 4 parts of bees'-wax, and 2 parts of powdered red ochre.

Those cells are afterwards filled almost to the top with water, or any other fluid, according to the foregoing table; and thus the whole will form a battery, consisting of various repetitions of silver, zinc, and fluid. Two or more of such batteries may be joined, as has been said of the preceding battery. See fig. 24.

It need hardly be observed, that instead of zinc, copper, and water, other combinations may be made according to the table. At present the last-described batteries are constructed with copper, zinc, and water mixed with a small proportion of nitric or muriatic acid. For the construction of such batteries it is immaterial whether the metals are quite pure or slightly alloyed.

The action of all these batteries is greatest when they are first completed or filled with the fluid; and it declines in proportion as the metal is oxidated, or the fluid loses its power. Hence, after a certain time, not only the fluid must be changed, but the metallic pieces must be cleaned by removing the oxidated surface; which is done either by filing or by rubbing them with sand or sand-paper, or by immersing them for a short time in diluted muriatic acid, and then wiping them with a coarse cloth. The metallic pieces of the battery, fig. 19, may be cleaned by the last method, and may be wiped by introducing a stick with a rag into the cells.

Thus much may be sufficient with respect to the construction of simple and compound galvanic arrangements. It is now necessary to state the effects of those combinations. Indeed, the mode of applying single galvanic circles, and their principal effects, have already been described; yet, for the sake of assisting the memory, it will be useful to collect those effects under the four following heads, in explanation of which we shall add such farther experiments and observations as could not with propriety be mentioned before.

(1) The action of a single galvanic circle affects the organs of living animals, or of animals recently dead, especially when one end of the combination is connected with a nerve, and the other end is connected with a muscle of the same limb.

(2) That action may be transmitted through good conductors of electricity, but not through electrics, or through less perfect conductors.

(3) It affects the electrometer by the intermediation of other instruments.

(4) That action increases, or otherwise modifies, the chemical agency of the bodies concerned, upon each other.

The limbs of animals, especially of frogs recently dead, are the most sensible instruments of galvanic powers; and, in fact, the simplest galvanic circles will affect them, when they will not produce any other decisive electrical effect.

The various powers of different simple circles may be ascertained by applying them to such animal preparations as have their vitality or irritability more or less exhausted. Thus Mr. Volta, in his letter to Gren, says, "If you take a frog, the head of which has been cut off, and which has been deprived of all life by thrusting a needle into the spinal marrow, and immerse it without skinning, taking out the bowels, or any other preparation, into two glasses of water, the rump into one, and the legs into the other as usual; it will be strongly agitated and violently convulsed when you connect the water in both glasses by a bow formed of very different metals, such as silver and lead, or, what is better, silver and zinc; but this will by no means be the case when the two metals are less different in regard to their powers, such as gold and silver, silver and copper, copper and iron, tin and lead. But what is more, the effect will be fully produced on this so little prepared frog, when you immerse in one of the two glasses the end of a bow merely of tin or zinc, and into the other glass the other end of this bow which has been rubbed over with a little alkali. You may perform the experiment still better with an iron bow, one end of which has been covered

with a drop of thin coating of nitrous acid; and beyond all expectation, when you take a silver bow, having a little sulphuret of potass adhering to its extremity."

When a single powerful galvanic combination of the second order is applied with one end to the tongue, and with the other fluid end to some other sensible part of the body, an acid taste is perceived on the tongue, which taste, by continuing the contact. becomes less distinct, and is even changed into an alkaline taste.

If a tin bason is filled with soap-suds, lime-water, or a strong ley, which is still better; and if you then lay hold of the bason with both your hands, having first moistened them with pure water. and apply the tip of your tongue to the fluid in the bason, you will immediately be sensible of an acid taste upon your tongue, which is in contact with the alkaline liquor. This taste is very perceptible, and, for the moment, pretty strong; but it is changed afterwards into a different one, less acid, but more saline and pungent, until at last it becomes alkaline and sharp, in proportion as the fluid acts more upon the tongue.

Mr. Davy observes, that if zinc and silver are made to form a circle with distilled water, holding in solution air, for many weeks, a considerable oxidation of the zinc is perceived, without the perceptible evolution of gas; and the water, at its point of contact with the silver, becomes possessed of the power of tinging green, red cabbage juice, and of rendering turbid, solution of muriate of magnesia.

The chemical action of bodies upon each other is increased by the galvanic arrangement so much, that some of them are by that means enabled to act upon bodies that otherwise they would have no action upon. Fig. 20. represents a glass tube about four inches long. Two corks are thrust into its apertures A and B. An oblong piece of zinc, CD, is fixed into one of the corks, and is made to project within and without the tube. EFG is a silver wire, which, being fixed into the other cork, projects with the extremity E within the tube; and its other extremity is bent so as to come near the projecting part of the zinc C.

Remove one of those corks, and fill the tube with water, in which you must mix a drop or two of muriatic acid; then replace the cork, and you will find that the zinc is acted upon by the diluted acid, is oxidated by it, and bubbles of gas are evolved from it; but the silver wire E remains untouched, and no gass whatever is evolved from it. Now, if you bend the silver wire FG, so that its end G may touch the zinc at C, then the galvanic circle of silver, zinc, and diluted acid is completed, in consequence of which the diluted acid is enabled to act stronger upon the zinc D, which is manifested by the more copious evolution of gas, and is besides enabled to act upon the silver wire; for now you will observe the evolution of gas from the siver E also. Break the contact between G and C, and the silver E will cease to yield gas. Form it again, and gas will again proceed from the silver.

Instead of silver, zinc, and diluted muriatic acid, you may in the same manner use gold, tin, and diluted nitric acid; and by completing the circle, the acid will be enabled to act upon the gold.

It has been observed, that whenever an oxidating influence is exerted at one of the places of contact of the perfect and imperfect conductors, a deoxidating action appears to be produced at the other place. Thus when iron, which oxidates rapidly when forming a circle with silver and common water, is arranged with zinc and common water, it remains perfectly unaltered, whilst the zinc is rapidly acted upon.

Such are the facts which have as yet been discovered with respect to the power of single galvanic circles. They form a remarkable addition to the science of electricity, and open a vast field of speculation and experimental investigation; yet we are unable to form a theory sufficient to account for the original cause, or for the action of that very remarkable power; and we can only wait with patience for the probable elucidation, which may be afforded by farther discoveries.

If the effects of single circles are very remarkable, the collected power of several single circles, or of the battery, cannot fail of surprising the least reflecting mind.

The battery not only convulses the prepared limbs of a frog, or produces the appearance of a flash of light before the human eye; but it shows all the phenomena of electricity in a very considerable degree. It gives the shock; it affects the electrometer; shows a luminous spark, accompanied with an audible report; it burns metallic and other combustible bodies; and continues in action for a very long time, viz. until the chemical action between the component parts of the battery is quite exhausted. The following paragraphs contain a more particular, yet concise, enumeration of these wonderful effects.

When the galvanic battery of the first order consists of 20 repetitions of simple combinations, if you touch with one hand one extremity of the battery, as at *b*, in any one of the above described batteries (See figs. 17, 18, 19), and apply your other hand to the other extremity of the battery, as at *a*, you will feel a very slight shock, like that which is communicated by a Leyden phial weakly charged, and it will be hardly felt beyond the fingers, or at most the wrists. This shock is felt as often as you renew the contact. If you continue the hands in contact with the extremities *b* and *a*, you will perceive a slight but continued irritation; and, when the hand or other part of the body, which touches the extremity of the battery, is excoriated or wounded, this sensation is disagreeable and rather painful.

The dry skin of the human body is seldom capable of conducting this shock; therefore the touching fingers should be well moistened with water. It will be better to immerse a wire that proceeds from one extremity of the battery, in a bason of water, wherein you may plunge one of your hands; then grasping with your other hand well moistened a large piece of metal, for instance a large silver spoon, touch the other end of the battery with it, and the shock will be felt more distinctly. By this means the shock has been felt when the battery consisted of less than twenty repetitions.

Instead of one person, several persons may join hands (which must be well moistened with water), and on completing the circuit, they will all feel the shock at the same instant. But the strength of the shock is much diminished by its passing through the several persons, or, in general, by passing through less perfect conductors.

The shock from a battery consisting of 50 or 60 repe-

titions of the most active combinations of the first order may be felt as far as the elbows; and the combined force of five or six such batteries will give a shock perhaps much stronger than most men would be willing to receive. The prepared limbs of a frog or other animal are violently convulsed, but soon exhausted of their irritability by the action of a galvanic battery.

This shock is similar to that of a large common electrical battery weakly charged, and not to that of a small Leyden phial fully charged. The difference consists in this, viz. that the latter contains a small quantity of electric fluid highly condensed; hence its discharge will force its way through perhaps an inch of air; whereas the former contains a vast quantity of electricity but little condensed; hence its sparks, viz. its course through the air, is so very short, that the fingers must be brought almost into perfect contact in order to receive the shock; and such is the case with the galvanic battery: for the shock from a very powerful battery of this sort will hardly ever force its way through the air, when the extremities of the circle of communication are more than a fortieth of an inch distant, even when those extremities consist of perfect conductors. In this case a small but very vivid spark is seen at that extremity, accompanied with an audible but not strong report. There is no perceptible difference of appearance between the spark of the positive and that of the negative end of the battery.

If a wire proceeding from one extremity of a pretty strong battery is made to communicate with the inside coating, and a wire, which proceeds from the other extremity of the battery, is made to communicate with the outside coating of a common large jar or electrical battery; the latter will become weakly, but almost instantaneously, charged, in the same manner as if it had been charged by a few turns of a common electrical machine; and with that charge you may either give the shock or affect on electrometer, &c.

In short, every thing conspires to prove that a galvanic battery produces a vast quantity of electric fluid, but which is little condensed; and indeed it would be impossible to suppose that the electric fluid could proceed in a very condensed state from an arrangement of bodies, which, whether more or less, are however all good conductors of electricity; for if the fluid was much condensed at one extremity of the battery, and much rarefied at the other extremity, the condensation would soon be made through the pile itself. Indeed, it is difficult to comprehend how this compensation does not take place in all cases.

Having mentioned above, that the charge of a battery may be communicated to a common electrical battery, it is almost superfluous to observe, that the same may be communicated to a condenser, or to a multiplier, and from it to the electrometer. If the battery consists of 200 repetitions, the electrometer will be affected by the simple contact.

The spark, or the discharge of a galvanic battery, when sent through thin inflammable bodies that are in contact with common or oxygen air, sets them on fire, and consumes them with wonderful activity. It fires gun-powder, hydrogen gas, phosphorus, and other combustibles; it renders red-hot, fuses, and consumes very slender metallic wires and metallic leaves. The mode of applying the power of the battery for such purposes is shown in fig. 21. where AB represents a powerful galvanic battery; ACDF is a wire which communicates with the last plate of the battery at A; BKIHG is another wire which communicates with the last plate at B. DE, HI, are two glass tubes, through which those wires pass, and into which they are fastened sufficiently steady. Those tubes serve to move the wires by; for if the operator applies his fingers to the middlemost parts of those tubes, he may move the wires wherever he pleases, without the fear of receiving a shock. If the two extremities F, G, are brought sufficiently near to each other, the spark will be seen between them. It is between those extremities that the combustible substances, or metalic leaf, &c. is to be placed, in order to be fired or consumed. This figure represents the situation of the wires in the act of inflaming gunpowder. A battery consisting of 200 pairs of metallic plates (viz. copper and zinc, each five inches square) melted 23 inches of very fine iron wire. A platina wire about $\frac{1}{175}$ inch in diameter, was melted into a globule. Fig. 24 is the representation of a compound battery of the same kind, fastened together with iron cramps *a, b, c*.

Under the exhausted receiver of the air pump, the galvanic battery acts less powerfully than in the open air; but in oxygen air it acts with increased power.

The flash of light which appears before the eye of the experimenter, when the eye itself, or some other part not very remote from it, is put in the circuit of a galvanic combination, does not appear much greater when a battery is employed than when two plates are applied in the manner which has been already mentioned; but when the battery is used, the sensation of a flash may be produced in various ways. If one hand or both be placed in perfect contact with one extremity of the battery, and almost any part of the face brought into contact with the other extremity of the battery, the flash will appear very distinctly, the experimenter being in the dark, or keeping his eyes shut. This flash appears very strong, when a wire which proceeds from one extremity of the battery is held between the teeth, and rests upon the tongue, whilst the other wire is held in the hand. In this case the lips and the tongue are convulsed, the flash appears before the eyes, and a very pungent taste is perceived in the mouth.

If any part of the human body, forming part of the circuit of a galvanic battery, is kept sometime in that situation, the irritation or numbness is more or less distinct, and more or less painful, according to the sensibility of the parts concerned. This application is likely to prove most useful as a remedy in various disorders. It is said that it has already proved beneficial in deafnesses and in rheumatisms. It highly deserves to be tried by medical persons. See fig. 25.

The most extraordinary phenomena of a galvanic battery are the chemical effects and the modifications which are produced by it upon the bodies concerned, or upon such as are placed in the circuit. We shall first describe the simplest mode of exhibiting the principal of those phenomena, namely, the evolution of gas from water, from which the mode of conducting similar experiments is easily derived; then shall transcribe the various particulars which relate to those chemical effects, from the

Journals of the British Royal Institution, where they are concisely expressed.

AB, fig. 22, exhibits a glass tube full of distilled water and having a cork at each extremity. EF is a brass or copper wire, which proceeds from one extremity of a galvanic battery, and, passing through the cork A, projects within the tube. HG is a similar wire, which proceeds from the other extremity of the battery, and comes with its extremity G within the distance of about an inch or two from the wire F.

In this situation of things, you will find that bubbles of gas proceed in a constant stream from the surface G of the wire which proceeds from the negative end of the battery; these bubbles of gas, ascending to the upper part of the tube, accumulate by degrees. This gas is the hydrogen, and may be inflamed. At the same time the other wire F deposits a stream of oxide in the form of a stream or cloud, which gradually accumulates in a greenish form in the water, or on the sides of the tube, and is a perfect oxide of the brass. The wire F is readily discoloured and corroded. If you interrupt the circuit, the production of gas and of oxide ceases immediately. Complete the circuit, and the production of gas re-appears.

This production of gas may be observed even where the battery consists of not more than six or eight repetitions of silver, zinc, and water. In short, if the power of the battery is sufficient to oxidate one of the wires of communication, the other wire will afford hydrogen gas; both extremities of the wires being in water.

In this experiment it seems that the hydrogen is separated from the water, and is converted into a gaseous state by the wire connected with the negative extremity of the battery; whilst the oxygen unites with and oxidates the wire connected with the positive end of the battery. If you connect the positive end of the battery with the lower wire of the tube, and the negative with the upper, then the hydrogen proceeds from the upper wire, and the lower wire is oxidated.

If the two wires of gold or platinum are used, which are not oxidable; then the stream of gas issues from each, the water is diminished, and the collected gas is found to be a mixture of hydrogen and oxygen. It explodes violently.

Those two different elastic fluids may be obtained separate from each other by the following means: Let the extremities of the two wires which proceed from the battery, be immersed in water, at the distance of about an inch from each other, and place over each of them a small glass vessel inverted and full of water, as in fig. 23. Dr. Priestley, however, who denies the convertibility of water into hydrogen and oxygen air, thinks that the elastic fluid in these experiments originates from the air which is contained in the water; "since," says he, "if by means of oil upon the water, or a vacuum, access to the atmosphere is cut off, the whole production of gas ceases." Nor is any air produced when the water has been exhausted of it.

In the above described apparatus, a little hole must be made in the lower cork B, for the purpose of giving exit to the water in proportion as the gas is formed.

In all batteries of the first order, when the connexion is completed, changes take place which denote the evolution of influences capable of producing from common water oxygen and hydrogen, acid and alkali, in different parts of the body.

Thus in the battery with a series of zinc plates, silver wires, and common water, oxide of zinc is formed on all the plates of zinc, whilst hydrogen is produced from the silver wires; and if the water in contact with them is tinged with red cabbage juice, it becomes green.

And in the battery with silver, gold, and weak nitric acid, the silver is dissolved, whilst the acid becomes green, and slowly evolves gas at its points of contact with the gold.

The chemical agencies exerted in the compound batteries of the first order can be best observed by the substitution of single metallic wires for some of the plates; for, in this case, the changes taking place in the series with wires, will be exactly analogous to those produced in the series with plates; silver, and all the more oxidable metals, oxidating in water, in the usual place, and gold and platina evolving oxygen gas.

Thus, when in two small glass tubes, connected by a moist animal substance, and filled with distilled water, two gold wires are introduced from a large battery in the proper order, oxygen is produced in one quantity of water, and hydrogen in the other, nearly in the proportions in which they are required to form water by combustion: and if the process is continued for some time, the apparatus being exposed to the atmosphere, the water, in the oxygen-giving tube, will become impregnated with an acid (apparently the nitrous); whilst that in the hydrogen-giving tube will be found to hold in solution an alkali, which, in certain cases, has appeared to be fixed.

From some experiments it would appear probable, that the quantities of hydrogen, produced in series, are small, and the quantities of alkali great, in proportion as the surfaces of contact of the least oxidable metals with the water are more extended.

All the oxygenated solutions of bodies possessing less affinity for oxygen than nascent hydrogen, are decomposed when exposed to the action of the metal occupying the place of the least oxidable part of the series in the compound circle.

Thus, sulphur may be produced from sulphuric acid; and copper and other metals precipitated in the metallic form from their solvents.

It is well known that hydrogen gas, in its nascent state, reduces the oxides of metals. Accordingly, when the tube. fig. 22. is filled with a solution of acetite of lead in distilled water, and a communication is made with the battery as above described, no gas is perceived to issue from the wire which proceeds from the negative end of the battery; but, in a few minutes, beautiful metallic needles are perceived on the extremity of this wire; these soon increase. and assume the form of a fern or other vegetable. The lead thus separated is in its perfect metallic state, and very brilliant.

When a solution of sulphat of copper is employed, the copper is precipitated in its metallic state; but instead of appearing in crystals, it forms a kind of button, which adheres firmly to the end of the wire.

On making the experiment with a solution of nitrate of silver, the silver is precipitated in the form of a beautiful metallic brush, the metal shooting into fine needle-like crystals.

If iron is immersed in a solution of sulphate of copper, the latter metal will be precipitated in a metallic form, and will adhere to the surface of the former. Upon silver merely immersed in the same solution, no such effect is produced; but as soon as the two metals, viz. the silver and the copper, are brought into contact, the silver receives a coating of copper.

Little knowledge has yet been obtained concerning the chemical changes taking place in the batteries of the second order. But from several experiments it would appear that they are materially different in the laws of their production from those taking place in the first order.

Thus, when single metallic wires with water are placed as series in powerful batteries of the second order, the influence producing oxygen seems to be transmitted by the point in the place of that part of the plate which was apparently incapable of undergoing oxidation; whilst the hydrogen is evolved from that point where the oxidating part of the primary series appeared to exist.

The agency of the galvanic influence, which occasions chemical changes and communicates electrical charges, is probably in some measure distinct from that agency which produces sparks and the combustion of bodies.

The one appears (all other circumstances being similar) to have little relation to surface in compound circles, but to be great in some unknown proportion, as the number of series are numerous. The intensity of the other seems to be as much connected with the extension of the surfaces of the series as with their number.

Thus, though eight series composed of plates of zinc and copper, about 10 inches square, and of cloths of the same size, moistened in diluted muriatic acid, give sparks so vivid as to burn iron wire, yet the shocks they produce are hardly sensible, and the chemical changes indistinct; whilst 24 series of similar plates and cloths, about two inches square, which occasion shocks and chemical agencies more than three times as intense, produce no light whatever.

A measure of the intensity of the power in galvanic batteries, producing chemical changes, may be derived from the quantity of gas it is capable of evolving from water in a given time.

The preceding facts can hardly leave any doubt with respect to the identity of the galvanic power and the electricity which is produced by means of a common electrical machine, or that is brought down from the clouds; but, what is still more remarkable, it reconciles to the same principle the animal electricity, viz. the power of the torpedo, gymnotus electricus, &c. since all the phenomena of the animal electricity agree with those of the galvanic battery. See ELECTRICITY.

But the most striking circumstance is, that the electric organ of any of the above-mentioned fishes seems to be constructed exactly like a galvanic battery; for it consists of little laminæ or pellicles arranged in columns, and separated by moisture. It seems, in short, to be a galvanic battery, consisting of conductors of the second order only, but undoubtedly of different conducting powers.

Though the galvanic battery exhibits all the leading properties of common electricity, such as the attraction, the spark, &c. yet in some effects, viz. the decomposition of water, oxygenation of metals, &c. the former seem to differ considerably from the latter; but those apparent differences have been sufficiently reconciled by some very ingenious experiments and observations of Dr. W. H. Wollaston. See Phil. Trans. 1801.

With respect to the decomposition of water, which was thought to require very powerful electrical machines, he justly suspected, that by reducing the surface of communication, the decomposition of water might be effected with less powerful means; and this was verified by actual experiments. "Having," he says, "procured a small wire of fine gold, and given it as fine a point as I could, I inserted it into a capillary glass tube; and after beating the tube so as to make it adhere to the point, and cover it in every part, I gradually ground it down, till, with a pocket-lens, I could discern that the point of the gold was exposed.

"The success of this method exceeding my expectations, I coated several wires in the same manner, and found that when sparks from the conductors were made to pass through water by means of a point so guarded, a spark passing to the distance of one-eighth of an inch would decompose water, when the point exposed did not exceed $\frac{1}{700}$ of an inch in diameter. With another point which I estimated at $\frac{1}{1500}$ of an inch, a succession of of sparks, $\frac{1}{20}$ of an inch in length, afforded a current of small bubbles of air.

"I have since found that the same apparatus will decompose water with a wire $\frac{1}{40}$ of an inch diameter, coated in the manner before described, if the spark from the prime conductor passes to the distance of $\frac{4}{10}$ of an inch of air."

He also found that with a gold point similar to, but much smaller than any of the above-mentioned, and similarly situated in water, the mere current of electricity, without any sparks, would occasion a stream of very small bubbles to rise from the extremity of the gold.

"Having coloured a card," he adds, "with a strong infusion of litmus, I passed a current of electric sparks along it, by means of two fine gold points, touching it at the distance of an inch from each other. The effect, as in other cases, depending on the smallness of the quantity of water, was most discernible when the card was nearly dry. In this state, a very few turns of the machine were sufficient to occasion a redness at the positive wire, very manifest to the naked eye. The negative wire being afterwards placed on the same spot, soon restored it to its original blue colour."

Dr. Wollaston likewise remarks another strong point of analogy between the electricity of the galvanic battery and that of a common electrical machine, viz. that they both seem to depend upon oxidation. In fact, a common electrical machine will act more or less powerfully, according as the amalgam which is applied to its rubber consists of metals that are more or less oxidable.

GAMBEZON, or GAMBA, in antiquity, a kind of soft quilted waistcoat, worn under the coat of mail to prevent its hurting the body. It was made of wool or cotton, quilted between two stuffs, and was also called counterpoint.

GAMBOGE, is a concreted vegetable juice, and is partly of a gummy and partly of a resinous nature. It

is brought to us either in form of orbicular masses, or of cylindrical rolls of various sizes, and is of a dense, compact, and firm texture, and of a beautiful yellow. It is chiefly brought to us from Cambaja, in the East Indies, called also Cambodja and Cambogia; and thence it has obtained its names of cambadium, cambogium, and gambogium.

It is a very rough and strong purge; it operates both by vomit and stool, and both ways with much violence, almost in the instant in which it is swallowed, but yet without griping. It requires caution and judgment in administering it; but those who know how to give it properly, find it an excellent remedy in dropsies, cachexies, jaundice, asthmas, catarrhs, and in the worst cutaneous eruptions.

Its dose is from two or three grains to six, eight, or ten: four grains generally operate briskly without vomiting, and eight or ten grains usually vomit briskly, and afterwards purge downwards.

It is at present much more esteemed by painters in water-colours than by physicians.

GAME, in general, signifies any diversion or sport that is performed with regularity, and restrained to certain rules.

Games are usually distinguished into those of address and those of hazard. To the first belong chess, tennis, billiards, wrestling, &c. and to the latter those performed with cards or dice, as back-gammon, ombre, picquet, whist, &c.

It would be a most salutary maxim to be adopted generally, that no game should be pursued but such as afforded exercise, and consequently contributed to the health of the body. In this view we greatly prefer such as tennis and billiards to the pernicious sedentary games at present pursued, which are only productive of gouts, palsies, &c.

Games, in antiquity, were public diversions, exhibited on solemn occasions. Such, among the Greeks, were the Olympic, Pythian, Isthmian, Nemæan, &c. games; and, among the Romans, the Apollinarian, Circensian, Capitoline, &c. games.

It was also customary among the Greeks for persons of quality to institute games, with all sorts of exercises, as running, wrestling, boxing, &c. at the funerals of their friends, to do them honour, and render their death more remarkable. This practice is frequently mentioned by ancient writers, as Miltiades's funeral in Herodotus, Brasidas's in Thucydides, Timoleon's in Plutarch, with many more. Nor was this custom peculiar to later ages, since we find the description of Patrocius's funeral games takes up the greatest part of one of Homer's Iliads; and even prior to this, the funeral of Œdipus is said to have been solemnized with sports.

Among the Romans, there were three sorts of games, viz. sacred, honorary, and ludicrous. The first were instituted immediately in honour of some deity or hero; of which kind were those already mentioned, together with the augustales, florales, palatini, &c. The second class were those exhibited by private persons at their own expense, in order to please the people, and ingratiate themselves with them, to make way for their own preferment: such were the combats of gladiators, the scenic games, and other amphitheatrical sports. The ludicrous games were much of the same nature with the games of exercise and hazard among us: such were the ludus trojanus, tesseræ, tali, trochus, &c.

By a decree of the Roman senate, it was enacted, that the public games should be consecrated and united with the worship of the gods; whence it appears, that feasts, sacrifices, and games, made up the greatest part, or rather the whole, of the external worship offered by the Romans to their deities. Others distinguish the Roman games into

1. The equestrian, or curule games, which were the same with the circensian. 2. The gymnic games, wherein were exhibited gladiatorial and other shows of the like nature: these were sacred to Mars and Minerva. 3. The theatrical entertainments, consisting of tragedies, comedies, &c.; these were sacred to Apollo, Bacchus, Minerva, Venus, &c.

Game. It is a maxim of the common law of England, that goods of which no person can claim any property belong to the king by his prerogative. Hence those animals feræ naturæ, which come under the denomination of game, are styled in our laws his majesty's game; and that which he has he may grant to another; in consequence of which another may prescribe to have the same, within such a precinct or lordship. And hence originated the right of lords of manors or others to the game within their respective liberties.

As the sole right of taking and destroying game belongs exclusively to the king, as such he may authorize the only persons who can acquire any property, however fugitive and transitory, in the animals coming under that denomination.

For the preservation of these species of animals; for the recreation and amusement of persons of fortune, to whom the king, with the advice and assent of parliament, has granted the same; and to prevent persons of inferior rank from misemploying their time, the following acts of parliament have been made. The common people are not injured by these restrictions, no right being taken from them which they ever enjoyed; but privileges are granted to those who have certain qualifications therein mentioned, which before rested solely in the king. 2 Bac. Abr. 612.

For the sake of perspicuity, we have arranged the different acts of parliament in alphabetical order.

Certificates to be dated the day of the month when issued, and shall be in force till the 1st of July following and no longer: and if any clerk of the peace, his deputy or steward, clerk, &c. issue certificates otherwise than directed, to forfeit 20*l*. 25 G. III. sess. 2.

No person to destroy game until he has delivered an account of his name and place of abode to the clerk of the peace, or his deputy, or to the sheriff or steward clerk of the county, riding, shire, stewartry, or place where such person shall reside, and annually take out a certificate thereof, which must have a stamp duty of 3*l*. 3*s*. 25 Geo. III. sess. 2.

Any person counterfeiting or forging any seal or stamp directed to be used by this act, with intent to defraud the revenue, or shall utter and sell such counterfeit, on conviction thereof shall be adjudged a felon, and shall suffer death without benefit of clergy; and all provisions of

former acts relative to stamp duties to be in force in executing this act. *Id.*

Every qualified person shooting at, killing, taking, or shooting any pheasant, partridge, heath-fowl, or black-game, or any grouse or red game, or any other game, or killing, taking or destroying any hare with any greyhound, hound, pointer, spaniel, setting-dog, or other dog, without having obtained such certificate, shall forfeit the sum of 20*l.* *Id.*

Clerks of the peace or their deputies, or the sheriff or steward clerks, in their respective counties, ridings, shires, stewartries, or places, shall, on or before November 1, 1785, or sooner if required by the commissioners of his majesty's stamp duties, transmit to the head office of stamps in London, a correct list in alphabetical order of the certificates by them issued between the 25th day of March, in the year 1785, and the 1st of October in the same year; and shall also in every subsequent year, on or before the 1st of August in each year, make out and transmit to the stamp-office in London, correct alphabetical lists of the certificates so granted by them, distinguishing the duties paid on each respective certificate so issued; and on delivery thereof, the receiver-general of the stamp duties shall pay to the clerk of the peace, &c. for the same one-halfpenny a name; and in case of neglect or refusal, or not inserting a full, true, and perfect account, he shall forfeit 20*l.* *Id.*

Lists may be inspected at the stamp-office for 1*s.* each search; *id.* which lists shall once or oftener in every year, be inserted in the newspapers in each respective county.

If any qualified person, or one having a deputation, shall be found in pursuit of game, with gun, dog, or net, or other engine for the destruction of game, or taking or killing thereof, and shall be required to show his certificate by the lord or lady of the manor, or proprietor of the land whereon such person shall be using such gun, &c. or by any duly-appointed game-keeper, or by any qualified or certified person, or by any officer of the stamps, properly authorized by the commissioners, he shall produce his certificate; and if such person shall refuse, upon the production of the certificate of the person requiring the same, to show the certificate granted to him for the like purpose; or in case of not having such certificate to produce, shall refuse to tell his christian and surname, and his place of residence, and the name of the county where his certificate was issued, or shall give in any false or fictitious name, he shall forfeit 50*l.* *Id.*

Certificates do not authorize any person to shoot at, kill, take or destroy any game at any time that is prohibited by law, nor give any person a right to shoot at, &c. unless he is duly qualified by law. *Id.*

No certificate obtained under any deputation shall be pleaded or given in evidence, where any person shall shoot at, &c. any game out of the manors or lands for which it was given. The royal family are exempted from taking out certificates for themselves or their deputies. *Id.*

Conies.—Destroying conies, transportation. 5 G. III. c. 14.

Robbing warrens, felony without clergy. 9 G. I. s. 22.

Killing them in the night, or endeavouring to kill them, fine of 10*s.* or commitment. 22 and 23 Car. II. c. 25.

Unqualified person using a gun to kill them, the same may be seized. 3 Jac. I. c. 13.

Deer.—Stalking deer without leave, 10*l.* 19 H. VII. c. 11.

Hunting or killing them, 10*l.*, costs, and sureties for good behaviour. 5 Eliz. c. 21.

Buck stalls or engines kept by unqualified persons may be seized. 3 Jac. I. c. 13.

Selling or buying them to sell again, 40*l.* 3 Jac. I. c. 27.

Coursing or killing them without consent, 20*l.* 13 Car. II. c. 10.

Hunting, taking, killing, or wounding, 30*l.* or transportation. 3 W. III. c. 10.; 5 G. I. c. 15.; 9 G. I. c. 22.; 10 G. II. c. 32.

Destroying pales or walls of inclosed grounds, without consent, 30*l.* 5 G. I. c. 15.

Keeper of parks privately killing or taking them, 50*l.* *Id.*

Robbing places where kept, felony without clergy. 9 G. I. c. 22.

Game-keepers.—All lords of manors, or other royalties, may appoint game-keepers, and empower them to kill game. 22 and 23 Car. II. c. 25.

But if game-keepers dispose of the game without the lord's consent, he shall be committed for three months, and kept to hard labour. 5 Anne, c. 14.

But no lord shall make above one game-keeper within one manor, with power to kill game, and his name shall be entered with the clerk of the peace; certificate whereof shall be granted by the clerk of the peace on payment of 10*s.* 6*d.* Unqualified game-keeper killing or selling hare, pheasant, partridge, moor, heath-game, or grouse, he shall forfeit 5*l.* by distress, or commitment for three months for the first offence, and every other four. 9 Anne, c. 21.

No lord shall appoint an unqualified game-keeper, or one who is not bona fide servant to such lord, or immediately employed and appointed to take and kill game for the use of the lord; other persons, under colour of authority for taking and killing game, or keeping any dogs or engines whatsoever for that purpose, shall forfeit 5*l.* in like manner. 3 G. I. c. 11.

Every deputation of a game-keeper to be registered with the clerk of the peace, or in the sheriff's or steward's court-books of the county, &c. where the lands lie, and annually take out certificate thereof, stamped with a half-guinea stamp (now 1*l.* 1*s.*). 25 Geo. III. sess. 2.

Every game-keeper, from and after the passing of this act, who shall deliver his name and place of abode as aforesaid, and require a certificate, shall be annually entitled thereto, stamped as before directed, from the clerk of the peace or his deputy, sheriff or steward, clerk, &c. to the effect of the form in the act set forth. *Id.*

Clerk of the peace, &c. after signing certificate, shall issue the same stamped, to the person registering the deputation, on requiring the same, for which he may receive 1*s.* *Id.*

If any person to whom any deputation or appointment of a game-keeper shall have been, or at any time thereafter shall be, granted, by any lord or lady of a manor, &c. shall, for the space of 20 days after the de-

putation or appointment shall be granted, neglect or refuse to register the same, and take out a certificate as aforesaid, he shall forfeit and pay the sum of 20*l.* to be applied as the law directs. *Id.*

Neglect or refusal of issuing certificates, incurs a forfeiture of 20*l.* recoverable in the courts of Westminster, court of session, of justiciary, or exchequer in Scotland, by action of debt or information, for the use of the plaintiff, with double costs of suit. *Id.*

Clerk of the peace, &c. may issue his certificate to any game-keeper first appointed in any year after 1st of July in that year. *Id.*

If any lord or lady of a manor, or proprietor of land, shall make any new appointment of a game-keeper, and shall register the deputation with the clerk of the peace, &c. and shall obtain a new certificate thereon, the first shall be void; and any person acting under the same, after notice, shall be liable to all the penalties of the game-laws, and those against unqualified persons. *Id.*

Hares.—Every person tracing or coursing hares in the snow shall be committed for one year (31 Eliz. c. 5.), unless he pay to the churchwardens, for the use of the poor, 20*s.* for every hare, or become bound by recognizances, with two sureties in 20*l.* apiece, not to offend again; and every person taking or destroying hares with any sort of engine, shall forfeit for every hare 20*s.* in like manner. 1 Jac. I. c. 27. Persons found using engines, liable to the punishment inflicted as above, by 31 Eliz. c. 5. Unqualified persons keeping or using sporting-dogs, or engines to kill or destroy hares, shall forfeit 5*l.* to the informer, with double costs (2 Geo. III. c. 19.), by distress, or be committed for three months for the first offence, and for every other four. 5 Anne, c. 14. Taking or killing hares in the night-time, forfeits 5*l.* (9 Anne, c. 25.), the whole to the informer, with double costs. 2 Geo. III. c. 19. Killing or taking with gun, dog, or engine, a hare in the night, between the hours of seven at night and six the morning, from October 12 to February 12, and between the hours of nine at night and four in the morning, from Feb. 12, to Oct. 12, or in the day-time upon Sunday or Christmas-day, to forfeit not less than 10*l.* nor more than 20*l.* for the first offence; nor less than 20*l.* nor more than 30*l.* for the second offence; and 50*l.* for the third offence, with costs and charges; and, upon neglect or refusal, be committed for six or twelve calender months, and may be publicly whipped; final appeal to the quarter-sessions. 13 Geo. III. c. 80. Persons armed and disguised stealing them, felony without clergy. Geo. I. c. 22. Higler, chapman, carrier, inn-keeper, victualler, or alehouse-keeper, having in his custody, or buying, selling, or offering to sale, any hare, unless sent up by some person qualified (or any person selling, exposing, or offering for sale hares, &c. 28 Geo. II. c. 22.) shall forfeit for every hare 5*l.*, the whole to the informer. 2 Geo. III. c. 92.

Heath-fowl.—For preserving heath-cocks or polts, no person whatsoever, on any waste, shall presume to burn, between Feb. 2 and June 24, any grig, ling, heath, furze, goss, or fern, on pain of commitment for a month or ten days, to be whipped and kept to hard labour. 4 and 5 W. and M. c. 23. Shooting heath-cocks, grouse, or moor-game, contrary to 1 Jac. I. c. 27. and killing any of them in the night, or using gun, dog, or engine, with such intent, contrary to 9 Anne, c. 25. and 13 Geo. III. c. 80.; and carriers and others having such in their possession, contrary to 9 Anne, c. 14. are all liable to the same penalties, and recoverable in the same manner, as those offences are subjected to shooting, &c. hares.

Partridges.—Taking partridges by nets or other engines, upon another's freehold, without special leave of the owner of the same, penalty 10*l.* half to him who shall sue, and half to the owner or possessioner. 11 H. VIII. c. 17. Shooting, &c. at partridges with gun or bow, or taking them, &c. with dogs or nets, by 7 Jac. I. c. 11. or taking their eggs out of their nest, liable as persons shooting, &c. at hares, and also 20*s.* for every bird or egg. Selling, or buying to sell again, a partridge (except reared and brought up in houses, or from beyond sea), forfeits for every partridge 10*s.* half to him who will sue, and half to the informer. 1 Jac. I. c. 27. Taking, killing, or destroying partridges in the night, forfeits for every partridge 10*l.* half to him who will sue, and half to the lord of the manor, unless he license or cause the said taking or killing, in which case his half shall go to the poor, recoverable by churchwardens; and if not paid in ten days, to be imprisoned for one month; and moreover shall give bond to the justice, with good sureties, not to offend again for two years. 23 Eliz. c. 10. to kill a partridge in the night, penalty 5*l.* 9 Anne, c. 25. The whole whereof is given to the informer (2 Geo. III. c. 19.) and may be recovered within three months (5 Anne, c. 14), before a justice of peace, or within six months, by action in the courts of record at Westminster (9 Anne, c. 25.) with double costs. 2 Geo III. c. 19. Keeping or using any greyhounds, setting dogs, or any engine for destroying partridges, penalty 5*l.* to be levied and recovered as the like penalty for killing hares. Penalties for using gun, dog, snare, net, or other engine, with intent to take or destroy partridges in the night, or on Sunday, or Christmas-day, same as using them against hares, by 13 G. III. c. 80. Carriers and others having partridges in their possession, liable to the same forfeitures and penalties as having hares; and the same law against shooting them by unqualified persons as for killing hares.

Pheasants.—All the laws respecting the penalties and recovery of them, for taking them by nets, snares, or other engines, without license of the owner, by 11 H. VIII. c. 17. and for shooting or destroying them with dogs or snares, &c. by 7 Jac. I. c. 11. or taking their eggs, by 1 Jac. I. c. 27. and for selling, and buying them to sell again, by last-cited act (except that the penalty for a pheasant is 20*s.*), and for destroying them in the night (except as aforesaid), by 23 Eliz. c. 10. 9 Anne, c. 25. and 13 G. III. c. 80. and for keeping or using sporting-dogs or engines for destroying them on Sunday or Christmas-day, by 13 G. III. c. 80. and for carriers and others having them in their possession. All these laws are, mutatis mutandis, verbatim the same as those respecting partridges.

Prosecutions.—Any one prosecuted for any thing done in pursuance of this act may plead the general issue, and give the special matter in evidence for his defence; and if upon trial verdict pass for the defendant, or plaintiff become nonsuited, defendant shall have treble costs of plaintiff. 25 Geo. III. sess. 2. s. 28.

Qualifications for killing game are, 1. having a freehold estate of 100*l.* per annum, 22 and 23 Car. II. c. 25.; 2. a leasehold estate for 99 years, of 150*l.* per annum; 3. the eldest son or heir apparent to an esquire, or person of superior degree; 4. the owner or keeper of a forest, park, chace, or warren. Unqualified person keeping dogs or engines to destroy game, to forfeit 5*l.* 5 Anne, c. 14.

No person (other than the king's son), unless he has lands of freehold to the value of five marks a year, shall have any game of swans, on pain of forfeiting them, half to the king, and half to any person so qualified, who shall seize the same. 22 Ed. IV. c. 6.

Any gentleman or other that may dispend 40*s.* a year freehold, may hunt and take wild fowls with their spaniels only, without using a net or other engine, except the long bow. 25 Hen. VIII. c. 11. From persons not having land of 40*s.* a year, or not worth in goods 200*l.* using gun or bow to kill deer, any person having 100*l.* may seize the same to his use. 3 Jac. I. c. 13.

Every person qualified to kill game, shall, previous to his shooting at, killing, or destroying any game, take out a certificate. See CERTIFICATE.

Sporting seasons.—The time for sporting in the day is from one hour before sun-rising until one hour after sun-setting. 10 G. III. c. 19.

For bustards, the sporting season is, from December 1 to March 1.

For grouse or red grouse, from August 11 to December 10.

Hares may be killed all the year, under the restriction, as to the hours of the day, in 10 Geo. III. c. 19.

Heath-fowl, or black game, from August 20 to December 20.

Partridges, from September 1 to February 12.

Pheasants, from October 1 to February 1.

Widgeons, wild ducks, wild geese, wild fowls, at any time but in June, July, August, and September.

Summary proceedings.—From and after March 1, 1785, in all cases where the penalty by this act does not exceed 20*l.* a justice of peace shall, upon information or complaint, summon the party and witnesses to appear, and proceed to hear and determine the matter in a summary way; and upon due proof by confession, or upon the oath of one witness, give judgment for the forfeiture, and issue his warrant for levying the same on the offender's goods, and to sell them, if not redeemed within six days, rendering to the party the overplus; and if his goods are insufficient to answer the penalty, shall commit the offender to prison, there to be for six calendar months, unless the penalty is sooner paid; and if the party is aggrieved by the judgment, he may, upon giving security amounting to the value of the forfeitures, with the costs of the affirmance, appeal to the next general quarter-sessions, when it is to be heard and finally determined; and in case the judgment is affirmed, the sessions may award such costs, incurred by the appeal, as to themselves shall seem meet. 25 Geo. III. sess. 2.

Witnesses neglecting or refusing to appear, without reasonable excuse to be allowed of by the justice, shall respectively forfeit for every offence 10*l.* to be levied and paid as other penalties by this act. *Id.*

Justice to cause conviction to be made out to the effect of the form set forth in the act. *Id.*

Justice may mitigate penalties as he thinks fit, so that reasonable costs and charges of the officers and informers for discovery and prosecution be always allowed, over and above mitigation, and so as the same does not reduce the penalties to less than a moiety over and above the costs and charges, any thing therein contained to the contrary notwithstanding; and no such conviction shall be removable by certiorari into any court whatsoever.

No offender against this act to be imprisoned more than three months. *Id.*

The duties to be paid to the receiver-general of the stamp-duties, and by him paid into the exchequer. *Id.*

Swans.—It is felony to take any swans that are lawfully marked, though they should be at large; and so it is unmarked swans, if they are domestic or tame, so long as they keep within a man's manor, or within his private river, or if they happen to escape from them, and are pursued and taken, and brought back again; but if they are abroad, and attain their natural liberty, then the property of them is lost, and so long felony cannot be committed by taking them. Burn's Just. tit. Game.

Wild fowl.—Same laws against shooting wild-fowl as for shooting hares, by 1 Jac. I. c. 27.

GAME-COCK, a fighting-cock, or one kept for sport, in the choice of which four things are chiefly to be regarded, viz. shape, colour, courage, and sharp heel.

1. As to shape, a game-cock must not be chosen either too large or too small: the first being generally unwieldy and inactive; the other weak and tedious in fighting. The middle-sized cock is therefore most proper for this purpose, as being strong, nimble, and easily matched; his head ought to be small, with a quick large eye, and a strong beak, which should be crooked, and in colour suitable to the plume of his feathers; the beam of his leg should be strong, and of the colour of his plume; his spurs should be rough, long, and sharp, a little bending, and pointing inward. 2. The best colour for a game-cock is either grey, yellow, or red; the pyed pile may pass indifferently; but the white and dun are rarely known to be good for any thing. If his neck is invested with a scarlet complexion it is a sign of his being strong, lusty, and courageous; whereas a pale and wan complexion denotes him faint and unhealthy. 3. His courage may be known by his proud, upright standing, and stately tread in walking; and if he crows frequently in the pen, it is a proof of spirit. 4. His sharpness of heel is known only from observations in fighting: that is, when at every rising he hits so that he draws blood from his adversary; gilding his spurs continually, and at every blow threatening him with immediate death.

To prepare a cock to fight: 1. With a pair of fine shears to cut all his mane off, close to his head, from the head to the setting of the shoulders. 2. Clip off all the feathers from the tail close to his rump, and the redder it appears, the better is the cock in condition. 3. Spread his wings by the length of the first rising feather; and cut off the rest slopewise, with sharp points, that in his rising he may therewith endanger an eye of his adversary. 4. See that there be no feathers on the crown of

his head for his opponent to take hold of; and moisten his head all over with your spittle.

GAME-KEEPERS. See GAME.

GAMELION, in ancient chronology, was the eighth month of the Athenian year, containing 29 days, and answering to the latter part of our January and beginning of February. It was thus called, as being, in the opinion of the Athenians, the most proper season of the year for marriage.

GAMING, the art of playing or practising any game, particularly those of hazards as cards, dice, tables, &c. It appears that by the ancient common law all games were lawful. But so early as the reign of Richard II. the legislature found it necessary to interfere, and to make several games illegal. This was levelled at labourers and artificers. The next statute was the 2nd Hen. IV. which inflicted six days imprisonment on those who offended against the act of Richard II. The 17th Edw. IV. imposes a penalty of two years imprisonment and a fine against various games there enumerated; and by the 11th Hen. VII. labourers and artificers are prohibited from playing at unlawful games, but in Christmas only. The principal object of these early statutes was, to encourage archery, and to make that the only lawful sport for the lower ranks of the people. But the earliest act against gaming now in force is the 33d Henry VIII. which gives justices of peace and head officers in corporations a power to enter all houses suspected of unlawful games, and to arrest the gamesters till they give security not to play for the future. Persons keeping any unlawful gaming-house, are fined 40*s.* and the gamesters 6*s.* 8*d.* a time. If any person by fraud, deceit, or unlawful device, in playing either at cards or dice, tables, bowls, cock-fighting, horse-races, &c. or bearing a share in the stakes or betting, shall win any money or valuable thing of another, he shall forfeit treble the value thereof: likewise if any person shall play at any of the said games upon tick, and not for ready money, and lose the sum of 100*l.* on credit, at one meeting, if the money is not paid down, his security taken for it shall be void, and the winner becomes liable to a forfeiture of treble value of such money won. 16 Car. II. c. 7. Not only all notes, bills, bonds, mortgages, or other securities given for money won at gaming, are declared void; but also where lands are granted, they shall go to the next person entitled, after the decease of the person so incumbering the same. Persons losing by gaming at one time 10*l.* may recover the money lost from the winner, by an action of debt brought within three months; and on the loser's not prosecuting, any other person may lawfully do it, and recover treble the value, with costs. 9 Anne, c. 14. Those who cheat at cards, dice, &c. besides their forfeitures, have inflicted on them such infamy and corporal punishment, as in cases of perjury; and beating, or challenging any other person to fight, on account of money won by gaming, shall forfeit all their goods, and be imprisoned two years: and where persons play that have no visible estates, and do not make it appear that the principal part of their maintenance is got by other means than gaming, they may be bound to their good behaviour by two justices of the peace, &c. Stat. ibid. See 2 Geo. II. c. 28. The ace of hearts, pharaoh, basset, &c. are judged to be lotteries by cards or dice; and persons who set up those games, are subject to 200*l.* penalty. And every adventurer, who shall play, stake, or punt at them, forfeits 50*l.* Also any sales of houses, goods, plate, &c. in such a way, are void, and the things forfeited to any who will sue for the same. 12 Geo. II. c. 28. See Disney's Laws of Gaming, Wagers, &c.

GAMING, *laws of.* These are founded on the doctrine of chances. See CHANCE.

Mr. de Moivre, in a treatise De Mensura Sortis, has computed the variety of chances in several cases that occur in gaming, the laws of which may be understood by what follows.

Suppose p the number of cases in which an event may happen, and q the number of cases wherein it may not happen, both sides have the degree of probability, which are to each other as p to q.

If two gamesters, A and B, engage on this footing, that if the cases p happen, A shall win; but if q happen, B shall win, and the stake be a; the chance of A will be $\frac{pa}{p+q}$, and that of B $\frac{qa}{p+q}$; consequently, if they sell the expectancies, they should have that for them respectively.

If A and B play with a single die, on this condition, that if A throw two or more aces at eight throws, he shall win; otherwise B shall win; what is the ratio of their chances? Since there is but one case wherein an ace may turn up, and wherein it may not, let $a = 1$, and $b = 5$. And again, since there are eight throws of the die, let $n = 8$; and you will have $\overline{a+b}^{n} - b^{n} - nab^{n-1}$, to $b^{n} + nab^{n-1}$: that is, the chance of A will be to that of B, as 663991 to 10156525, or nearly as 2 to 3.

A and B are engaged at single quoits, and after playing some time, A wants 4 of being up, and B 6; but B is so much the better gamester, that his chance against A upon a single throw would be as 3 to 2; what is the ratio of their chances? Since A wants 4, and B 6, the game will be ended at nine throws; therefore, raise $a + b$ to the ninth power, and it will be $a^9 + 9a^8b + 36a^7bb + 84a^6b^3 + 126a^5b^4 + 126a^4b^5$, to $84a^3b^6 + 36aab^7 + 6ab^8 + b^9$; call a 3, and b 2, and you will have the ratio of chances in numbers, viz. 1759077 to 194048.

A and B play at single quoits, and A is the best gamester, so that he can give B 2 in 3, what is the ratio of their chances at a single throw? Suppose the chances as z to 1, and raise $z + 1$ to its cube, which will be $z^3 + 3z^2 + 3z + 1$. Now, since A could give B 2 out of 3, A might undertake to win three throws running, and, consequently, the chances in this case will be as z^3 to $3z^2 + 3z + 1$. Hence $z^3 = 3z^2 + 3z + 1$; or, $2z^3 = z^3 + 3z^2 + 3z + 1$. And therefore, $z\sqrt[3]{2} = z + 1$; and, consequently, $z = \frac{1}{\sqrt[3]{2} - 1}$. The chances, therefore, are $\frac{1}{\sqrt[3]{2} - 1}$, and 1, respectively.

Again, Suppose I have two wagers, depending, in the first of which I have 3 to 2 the best of the lay, and in the second 7 to 4, what is the probability I win both wagers?

1. The probability of winning the first is $\frac{3}{5}$, that is, the number of chances I have to win, divided by the number of all the chances: the probability of winning the se-

cond is $\frac{7}{11}$: therefore, multiplying these two fractions together, the product will be $\frac{21}{55}$, which is the probability of winning both wagers. Now, this fraction being subtracted from 1, the remainder is $\frac{34}{55}$, which is the probability I do not win both wagers; therefore the odds against me are 34 to 21.

2. If I would know what the probability is of winning the first, and losing the second, I argue thus: the probability of winning the first is $\frac{3}{5}$, the probability of losing the second is $\frac{4}{11}$; therefore multiplying $\frac{3}{5}$ by $\frac{4}{11}$, the product $\frac{12}{55}$ will be the probability of my winning the first, and losing the second; which being subtracted from 1, there will remain $\frac{43}{55}$, which is the probability I do not win the first, and at the same time lose the second.

3. If I would know what the probability is of winning the second, and at the same time losing the first, I say thus: the probability of winning the second is $\frac{7}{11}$; the probability of losing the first is $\frac{2}{5}$: therefore, multiplying these two fractions together, the product $\frac{14}{55}$ is the probability I win the second, and also lose the first.

4. If I would know what the probability is of losing both wagers, I say, the probability of losing the first is $\frac{2}{5}$, and the probability of losing the second $\frac{4}{11}$; therefore, the probability of losing them both is $\frac{8}{55}$; which being subtracted from 1, there remains $\frac{47}{55}$: therefore, the odds of losing both wagers is 47 to 8.

This way of reasoning is applicable to the happening or failing of any events that may fall under consideration. Thus, if I would know what the probability is of missing an ace four times together with a die, this I consider as the failing of four different events. Now the probability of missing the first is $\frac{5}{6}$, the second is also $\frac{5}{6}$, the third $\frac{5}{6}$, and the fourth $\frac{5}{6}$; therefore the probability of missing it four times together is $\frac{5}{6} \times \frac{5}{6} \times \frac{5}{6} \times \frac{5}{6} = \frac{625}{1296}$; which being subtracted from 1, there will remain $\frac{671}{1296}$, for the probability of throwing it once or oftener in four times; therefore the odds of throwing an ace in four times, is 671 to 625.

But if the flinging of an ace was undertaken in three times, the probability of missing it three times would be $\frac{5}{6} \times \frac{5}{6} \times \frac{5}{6} = \frac{125}{216}$; which being subtracted from 1, there will remain $\frac{91}{216}$ for the probability of throwing it once or oftener in three times; therefore the odds against throwing it in three times are 125 to 91.

Again, suppose we would know the probability of throwing an ace once in four times, and no more: since the probability of throwing it the first time is $\frac{1}{6}$, and of missing it the other three times is $\frac{5}{6} \times \frac{5}{6} \times \frac{5}{6}$, it follows that the probability of throwing it the first time, and missing it the other three successive times, is $\frac{1}{6} \times \frac{5}{6} \times \frac{5}{6} \times \frac{5}{6} = \frac{125}{1296}$; but because it is possible to hit it every throw as well as the first, it follows, that the probability of throwing it once in four throws, and missing the other three, is $\frac{4 \times 125}{1296} = \frac{500}{1296}$; which being subtracted from 1, there will remain $\frac{796}{1296}$ for the probability of throwing it once, and no more, in four times. Therefore, if one undertake to throw an ace once, and no more, in four times, he has 500 to 796 the worst of the lay, or 5 to 8 very near.

Suppose two events are such, that one of them has twice as many chances to come up as the other, what is the probability that the event which has the greater number of chances to come up, does not happen twice before the other happens once, which is the case of flinging 7 with two dice before 4 once? Since the number of chances are as 2 to 1, the probability of the first happening before the second is $\frac{2}{3}$, but the probability of its happening twice before it, is but $\frac{2}{3} \times \frac{2}{3}$, or $\frac{4}{9}$; therefore it is 5 to 4 seven does not come up twice before four once.

But if it were demanded, what must be the proportion of the facilities of the coming up of two events, to make that which has the most chances come up twice, before the other comes up once, the answer is 12 to 5 very nearly: whence it follows, that the probability of throwing the first before the second is $\frac{12}{17}$, and the probability of throwing it twice is $\frac{12}{17} \times \frac{12}{17}$, or $\frac{144}{289}$; therefore, the probability of not doing it is $\frac{145}{289}$: therefore the odds against it are as 145 to 144, which comes very near an equality.

Suppose there is a heap of thirteen cards of one colour, and another heap of thirteen cards of another colour, what is the probability that, taking one card at a venture out of each heap, I shall take out the two aces?

The probability of taking the ace out of the first heap is $\frac{1}{13}$, the probability of taking the ace out of the second heap is $\frac{1}{13}$; therefore the probability of taking out both aces is $\frac{1}{13} \times \frac{1}{13} = \frac{1}{169}$, which being subtracted from 1, there will remain $\frac{168}{169}$: therefore the odds against me are 168 to 1.

In cases where the events depend on one another, the manner of arguing is somewhat altered. Thus, suppose that out of one single heap of thirteen cards of one colour, I should undertake to take out first the ace; and, secondly, the two: though the probability of taking out the ace be $\frac{1}{13}$, and the probability of taking out the two be likewise $\frac{1}{13}$; yet, the ace being supposed as taken out already, there will remain only twelve cards in the heap, which will make the probability of taking out the two to be $\frac{1}{12}$; therefore the probability of taking out the ace, and then the two, will be $\frac{1}{13} \times \frac{1}{12}$.

In this last question the two events have a dependance on each other, which consists in this, that one of the events being supposed as having happened: the probability of the other's happening is thereby altered. But the case is not so in the two heaps of cards.

If the events in question be n in number, and be such as have the same number a of chances by which they may happen, and likewise the same number b of chances by which they may fail, raise $a+b$ to the power n. And if A and B play together, on condition that either one or more of the events in question happen, A shall win, and B lose, the probability of A's winning will be $\frac{\overline{a+b}|^{n} - b^{n}}{\overline{a+b}|^{n}}$; and that of B's winning will be $\frac{b^{n}}{\overline{a+b}|^{n}}$; for when $a+b$ is actually raised to the power n, the only term in which a does not occur is the last b^{n}: therefore, all the terms but the last are favourable to A.

Thus, if $n = 3$, raising $a+b$ to the cube $a^3 + 3a^2b + 3ab^2 + b^3$, all the terms but b^3 will be favourable to A; and therefore the probability of A's winning will be $\frac{a^3 + 3a^2b + 3ab^2}{\overline{a+b}|^{3}}$, or $\frac{\overline{a+b}|^{3} - b^3}{\overline{a+b}|^{3}}$; and the probability of

B's winning will be $\frac{b^3}{\overline{a+b}|^3}$. But if A and B play on condition, that if either two or more of the events in question happen, A shall win; but in case one only happen, or none, B shall win; the probability of A's winning will be $\frac{\overline{a+b}|^n - nab^{n-1} - b^n}{\overline{n+b}|^n}$; for the only two terms in which *aa* does not occur, are the two last, viz. nab^{n-1} and b^n. See CHANCE.

GAMMONING, among seamen, denotes several turns of rope taken round the bowsprit, and reeved through holes in knees of the head, for the greater security of the bowsprit.

GAMMUT, in music, the name given to the table or scale laid down by Guido, and to the notes of which he applied the monosyllables *ut, re, mi, fa, sol, la*. Having added a note below the proslambanomenos, or lowest tone of the ancients, he adopted for its sign the gamma, or third letter of the Greek alphabet; and hence his scale was afterwards called gammut. This gammut consisted of twenty notes, viz. two octaves and a major-sixth. The first octave was distinguished by capital letters, as G, A, B, &c. the second by small letters, *g, a, b*, &c. and the supernumerary sixth by double letters, as *gg, aa, bb*, &c. By the word gammut, we now generally understand the whole present existing scale; and to learn the names and situations of its different notes is to learn the gammut. It. however, sometimes simply signifies the lowest note of the Guidonian or common compass.

GANG, in the sea language, the same with crew. The company with which a ship's boat is manned is called the cockswain's crew or gang.

GANG, or GANGUE, in mineralogy. The word gang is used by German mineralogists to denote a metallic vein. Now, it is not often that these veins consist entirely of ore; in general they contain stony matter besides. For instance, in the copper-mine at Airthry, near Stirling, the copper ore is merely a narrow stripe in the middle of the vein, and the rest of it is filled up with sulphat of barytes. We use the word *gangue* as the French do, to denote not the metallic vein, but the stony matter which accompanies the ore in the vein. The gangue of the copper ore at Airthry is sulphat of barytes.

GANG-WAY, is the several passages or ways from one part of the ship to the other; and whatever is laid in any of those passages is said to lie in the gang-way.

GANGLIO, or GANGLION. See SURGERY.

GANGRENE. See SURGERY.

GANTLET, or GAUNTLET, a large kind of glove made of iron, and the fingers covered with small plates. It was formerly worn by cavaliers, when armed at all points.

GAOL. Gaols are of such universal concern to the public, that none can be erected by any less authority than an act of parliament. 2 Inst. 705.

All prisons and gaols belong to the king, although a subject may have the custody or keeping of them. 2 Inst. 100.

The justices of the peace at their general quarter-sessions, or the major part of them, provided that such major part shall not be less than seven, upon presentment made by the grand jury at the assizes of the insufficiency, inconvenience, or want of repair of the gaol, may contract for the building, repairing, or enlarging the same, together with the yards, courts, and outlets thereof, and adding such other building, and making such conveniences, as shall be thought requisite; or for erecting any new gaol within any distance not exceeding two miles from the site, and in that case for selling the old gaol and the site thereof, and also the materials of the old gaol; the contractors giving security to the clerk of the peace for the performance of the contract. 24 Geo. III. c. 54.

The expense of building, rebuilding, or enlarging such gaols, and such other necessary incidental expenses as aforesaid, shall be paid out of the county-rate; and when the account of such expense shall exceed half the amount of the ordinary annual assessment for the county rate (to be computed at a medium for the last proceeding five years), the justices in session may borrow in mortgage of the said rates any sum not less than 50*l*. nor exceeding 100*l*. and may order the growing interest and so much of the principal sum as shall be equal at least to such interest, to be paid off yearly, till the whole thereof shall be discharged, and an account thereof shall be kept in a book provided for that purpose; and such book shall be delivered into court at every quarter-session to be inspected by the justices, who shall make such orders relating thereto as to them shall seem meet: provided that the whole sum of money borrowed be fully paid within fourteen years from the time of borrowing it. *Id.*

As there are several persons confined in the county and city gaols under sentence and order made by one or more justices at their sessions, or otherwise, upon conviction in a summary way without the intervention of a jury; it is therefore, by 24 Geo. III. *c.* 56., enacted, that any judge of assize, or two justices, within whose jurisdiction such gaol is situated, may remove such persons to any house of correction within the same jurisdiction, there to be confined, and to remain in execution of such sentence or order.

For the relief of prisoners in gaols, justices of the peace in sessions have power to tax every parish in the county, not exceeding 6*s*. 8*d*. per week, leviable by constables, and distributed by collectors, &c. 12 Car. II. c. 29.

But it is observed by lord Coke, that the gaoler cannot refuse the prisoner victuals, for he ought not to suffer him to die for want of sustenance. 1 Inst. 295.

If any subject of this realm shall be committed to prison for any criminal or supposed criminal matter, he shall not be removed thence, unless by habeas corpus, or some other legal writ; or where he is removed from one prison or place to another within the same county, in order to his trial or discharge; or in case of sudden fire or infection, or other necessity; on pain that the person signing any warrant for such removal, and he who executes the same, shall forfeit to the party grieved 100*l*. for the first offence, and 200*l*. for the second, &c.

GAOL OF PRISON BREAKING, at the common law, was

felony, for whatever cause the party was imprisoned; but by 1 Ed. II. st. 2. the severity of the common law is mitigated, which enacts, that no person shall have judgment of life or member, for breaking prison, unless committed for some capital offence; so that, unless the commitment is for treason or felony, the breaking of prison is not felony, but is otherwise punishable as a misdemeanor only, by fine and imprisonment. 4 Black. 130.

Any place whatever, wherein a person under a lawful arrest for a supposed crime is restrained of his liberty, whether in the stocks or street, or in the common gaol, or the house of a constable, or a private person, is a prison in this respect, for a prison is nothing else but a restraint of liberty; and therefore this extends as well to a prison in law, as to a prison in deed. 2 Inst. 589.

He that breaks prison may be proceeded against for such a crime, before he is convicted of the crime for which he is committed, because the breach of prison is a distinct independant offence; but the sheriff's return of a breach of prison is not a sufficient ground to arraign a man without an indictment. 2 Haw. 197.

It is not sufficient to indict a man generally for having feloniously broken prison; but the case must be set forth specially, that it may appear that he was lawfully in prison, and for a capital offence. 2 Inst. 591. Hale's P. C. 109.

GAOLER. Besides the duties enjoined on gaolers by act of parliament, and the abuses for which by statute they are punishable, the common law subjects them to fine and imprisonment, as also to the forfeiture of their offices, for gross and palpable abuses in the execution of their offices. 2 Inst. 381.

Also gaolers are punishable by attachment, as all other officers are, by the courts to which they more immediately belong, for any gross misbehaviour in their offices, or contempt of the rules of such courts, and punishable by any other courts for disobeying writs of habeas corpus awarded by such courts, and not bringing up the prisoner at the day perfixed by such writs. 2 Haw. 151.

If the gaoler, by keeping the prisoner more strictly than he ought, occasions the prisoner's death, this is felony in the gaoler by the common law. Therefore, if a prisoner dies in gaol, the coroner ought to sit upon him; and if the death was occasioned by cruel and oppressive usage on the part of the gaoler, or any officer of his, it will be deemed wilful murder in the person guilty of such duress. 3 Inst. 91.

But if a criminal endeavouring to break gaol, assaults the gaoler, he may be lawfully killed by him in the affray. Jenk. 23. 1 Haw. 71.

A gaoler is considered as an officer relating to the administration of justice, and is under the same special protection of the law that other ministers of justice are. If a person threatens him for keeping a prisoner in safe custody, he may be indicted, and fined and imprisoned for it. 2 Rol. Abr. 71.

If in the necessary discharge of his duty he should meet with resistance, whether from prisoners in civil or criminal suits, or from others in behalf of such prisoners, he is not obliged to retreat as far as he can with safety, but may freely and without retreating repel force with force; and if the party so resisting happens to be killed, this will be justifiable homicide in the gaoler or his officer, or any person coming in aid of him. On the other hand, if the gaoler or his officer, or any person in aid of him, should fall in the conflict, this will amount to wilful murder in all persons joining in such resistance; for it is homicide in defiance of the justice of the kingdom. Fost. 321.

The justices in their sessions, or in any special adjournment held for such express purpose, may, if they shall think it necessary or proper, appoint salaries or allowances to gaolers, in lieu of the profits derived from the sale of liquors, as to them shall seem meet, and order the same to be paid out of the county-rate, by a certificate of such allowance being signed by the chairman of the sessions: but no chairman shall sign such certificate, unless notice of such intended application, signed by the clerk of the peace, has been given 14 days at least before the holding of such session or adjournment thereof, by two several advertisements in some newspaper which shall be printed and circulated in such county. 24 Geo. III. c. 54.

It seems clearly agreed, that a gaoler, by suffering voluntary escapes, by abusing his prisoners, by extorting unreasonable fees from them, or by detaining them in gaol after they have been legally discharged, and paid their just fees, forfeits his office; for that in the grant of every office it is implied, that the grantee executes it faithfully and diligently. Co. Lit. 233.

GAOL-DELIVERY. By the law of the land, that men might not be long detained in prison, but might receive full and speedy justice, commissions of gaol-delivery are issued out, directed to two of the judges, and the clerk of assize associate; by virtue of which commission, they have power to try every prisoner in the gaol, committed for any offence whatsoever.

GARBE, in heraldry, a sheaf of any kind of grain, said to represent summer, as a bunch of grapes does autumn.

GARBOARD-STRAKE, the plank next the keel of a ship, one edge of which is run into the rabbit made in the upper edge of the keel on each side.

GARCINIA, a genus of the monogynia order, in the dodecandria class of plants, and in the natural method ranking under the 18th order, bicornes. The calyx is tetraphyllous inferior: there are four petals: the berry is octospermous, and crowned with a shield-like stigma. There are three species. The mangostana is a tree of great elegance, and producing the most pleasant fruit of any yet known.

This tree has been very accurately described by Dr. Garcin, in honour of whom, as its most accurate describer, Linnæus gave it the name of Garcinia, in the 35th volume of the Philosophical Transactions. It grows, he informs us, to about 17 or 18 feet high, "with a straight taper stem like a fir," having a regular tuft in form of an oblong cone, composed of many branches and twigs, spreading out equally on all sides without leaving any hollow. Its leaves, he observes, are oblong, pointed at both ends, entire, smooth, of a shining green on the upper side, and of an olive on the back. Its flower is composed of four petals almost round or a little pointed: its colour resembles that of a rose, only deeper and less lively. The calyx of the flower is of one piece, expanded, and cut into four lobes. The two upper lobes are

something larger than the lower ones: they are greenish on the outside, and of a fine deep red within: the red of the upper ones is more lively than that of the lower ones. This calyx incloses all the parts of the flower; it is supported by a pedicle, which is green, and constantly comes out at the end of a twig above the last pair of leaves. The fruit is round, of the size of a small orange, from an inch and a half to two inches diameter. The body of this fruit is a capsule of one cavity, composed of a thick rind a little like that of a pomegranate, but softer, thicker, and fuller of juice. Its thickness is commonly a quarter of an inch. Its outer colour is of a dark-brown purple, mixed with a little grey and dark-green. The inside of the peel is of a rose-colour, and its juice is purple. Last of all, this skin is of a styptic or astringent taste, like that of a pomegranate; nor does it stick to the fruit it contains. The inside of this fruit is a furrowed globe, divided into segments much like those of an orange, but unequal in size, which do not adhere to each other. The number of these segments is always equal to that of the rays of the top which covers the fruit. The fewer there are of these segments the larger they are. There are often in the same fruit segments as large again as any of those that are on the side of them. These segments are white, a little transparent, fleshy, membranous, full of juice like cherries or raspberries, of a taste of strawberries and grapes together. Each of the segments incloses a seed of the figure and size of an almond stripped of its shell, having a protuberance on one of its sides. These seeds are covered with two small skins, the outermost of which serves for a basis to the filaments and membranes of which the pulp is composed. The substance of these seeds comes very near to that of chesnuts, as to their consistency, colour, and astringent quality.

"This tree (according to our author) originally grows in the Molucca islands, where it is called mangostan, but has been transplanted to the islands of Java and Malacca, at which last place it thrives very well. Its tuft is so fine, so regular, so equal, and the appearance of its leaves so beautiful, that it is at present looked upon at Batavia as the most proper for adorning a garden, and affording an agreeable shade. There are few seeds, however, (he observes) to be met with in this fruit that are good for planting, most part of them being abortive." He concludes his description by mentioning that one may eat a great deal of this fruit without any inconvenience; and that it is the only one which sick people may be allowed without any scruple.

Other writers concur in their praise of this fruit. Rumphius observes, that the mangostan is universally acknowledged to be the best and wholesomest fruit that grows in India; that its flesh is juicy, white, almost transparent, and of as delicate and agreeable a flavour as the richest grapes; the taste and smell being so grateful that it is scarcely possible to be cloyed with eating it. He adds, that when sick people have no relish for any other food, they generally eat this with great delight; but should they refuse it, their recovery is no longer expected. "It is remarkable (says he) that the mangostan is given with safety in almost every disorder. The dried bark is used with success in the dysentery and tenesmus, and an infusion of it is esteemed a good gargle for a sore mouth or ulcers in the throat. The Chinese dyers use this bark for the ground or basis of a black colour, in order to fix it the firmer."

According to captain Cook, in his Voyage round the World, vol. iii. p. 737, the garcinia mangostana of Linnæus is peculiar to the East Indies. It is about the size of the crab-apple, and of a deep red-wine colour. On the top of it is the figure of five or six small triangles joined in a circle, and at the bottom are several hollow green leaves, which are remains of the blossom. When they are to be eaten, the skin or rather flesh must be taken off, under which are found six or seven white kernels, placed in a circular order; and the pulp with which these are enveloped is the fruit, than which nothing can be more delicious. It is a happy mixture of the tart and the sweet, which is no less wholesome than pleasant, and, as well as the sweet orange, is allowed in any quantity to those who are afflicted with fevers either of the putrid or inflammatory kind.

GARDENIA, a genus of the pentandria monogynia class and order. The corolla is one-petalled, contorted or twisted; stigma lobed; berry inferior, two or four celled, many-seeded. There are 15 species, chiefly shrubs of the Cape and Japan. They are known in our stoves by the name of Cape jasmin, and some of them are highly ornamental. They are propagated by cuttings, plunged in a hotbed, &c.

GARDENING. This art, so natural to man, so improving to health, so conducive to the comforts and the best luxuries of life, may properly be divided into two branches; practical, and picturesque or landscape gardening.

The former is what every person, except the inhabitants of populous cities, has more or less occasion to practise; the latter is a privilege which only the very opulent can enjoy, and which must consequently be the elegant amusement of a chosen few.

Picturesque or landscape gardening should certainly never be attempted on a small scale. Indeed we are not certain that we may not be incurring a solecism in applying the term gardening to this department of agriculture. It is properly the art of laying out grounds; and the park or the farm, not the garden, is its object. It never can be attempted with success on a smaller scale than 20 acres; but 50 or 100, or even more, are better adapted to the design.

That style of gardening which would unite both objects, and which would give a picturesque effect to an acre or two of ground, is truly absurd. Many an improvident citizen wastes unprofitably the morsel of earth which should grow cabbages for his family, on an unprofitable grass-plat or shrubbery, on serpentines and mazes, and fish-ponds; or even on cascades, to the infinite annoyance of his visitors, the prejudice of his own health, and the merriment of all persons of true taste. This mania for the picturesque would have been not less deserving the ridicule of an Addison, than the perverse taste which displayed our first parents in yew, and the Graces and Muses in Portugal laurel.

A garden, properly speaking, is a small spot of ground attached to the house. As the house is itself a regular and formal object, so we naturally expect something of the same regularity in this appendage. Neatness too is

one of the chief excellencies of a garden, and this is found to be wholly inconsistent with this rage for the picturesque. Littered walks, and parched and cankered vegetables, with a wretched patch of green in the middle where a weekly exhibition is made from the buck-basket, are the usual effects of this rus-in-urbe taste; while all the real beauty, neatness, and utility, which a small spot of ground is really capable of affording, are preposterously neglected.

It is also fashionable to make a separation between the pleasure and the kitchen garden. This may indeed preserve the few shrivelled fruit which the latter, on a diminutive scale, is capable of affording, from the hands of rapacious visitors; but the range of the proprietor becomes by this appointment most deplorably limited and diminished; and the vegetables will want what alone can render them fine and flourishing, the free circulation of air.

For our own parts we cannot enter into that fastidiousness of taste, which can see no beauty in the esculent vegetables. There is a variety, and often a beauty, in their foliage, not inferior to the furniture of a shrubbery. The common pea, was it an exotic, would be admired for its milk-white blossom; and the bean for its agreeable fragrance. Few hot-house plants can vie in colour, or even in habit and growth, with the scarlet runner; and even the plants of more humble growth are not wholly destitute of beauty.

The garden of which we shall in the first place treat, as taking that practical view of the subject which is consistent with our design, is one in which vegetables, fruits, and flowers, are cultivated under the same inclosure. The work of making a new garden can happen to few; and when it does, soil, situation, and space, all favourable, are happy circumstances not always at command. It often happens, however, that pieces of ground are taken into use as additions; and some judgment should be exercised in the choice, that the business may be well effected.

With respect to the extent, a general idea may be given in observing, that an acre with wall-trees, hot-beds, pots, &c. will furnish employment for a man, who at some busy times will even need assistance. The size of the garden should, however, be proportioned to the house, as to the number of inhabitants it does or may contain. This is naturally dictated; but yet it is better to have too much ground allotted than too little, and there is nothing monstrous in a large garden annexed to a small house.

Some families use few, others many vegetables, and it makes a great difference whether the owner is curious to have a long season of the same production, or is content to have a supply only at the more common times. But to give some rule for the quantity of ground to be laid out, a family of four persons (exclusive of servants) may have a rood of good working open ground, and so in proportion.

But if possible let the garden be rather extensive according to the family; for then a useful sprinkling of fruit-trees can be planted in it, which may be expected to do well, under the common culture of the ground about them; a good portion of it also may be allotted for that agreeable fruit the strawberry in all its varieties; and the very disagreeable circumstance of being at any time short of vegetables will be avoided. It should be considered also, that artichokes, asparagus, and a long succession of peas and beans, require a good deal of ground. Hotbeds will also take up some room, if any thing considerable is done in the way of raising cucumbers, melons, flowers, &c.

The situation of a garden should be dry, but rather low than high, and as sheltered as can be from the north and east winds. These points of the compass should be guarded against by high and good fences; by a wall of at least ten feet high; lower walls do not answer so well for fruit-trees, though one of eight may do. A garden should be so situated, to be as much warmer as possible than the general temper of the air is without, or ought to be made warmer by the ring and subdivision fences. This advantage is essential to the expectation we have from a garden locally considered.

As to trees planted without the wall, to break the wind, we cannot expect to reap much good this way, except from something more than a single row, *i. e.* a plantation. Yet the fall of the leaves by the autumnal winds is troublesome, and a high wall is therefore advisable. Spruce firs have been used in close-shorn hedges; which, as evergreens, are proper enough to plant for a screen in a single row, though not very near to the wall; but the best evergreens for this purpose are the evergreen oak and the cork-tree. The witch elm, planted close, grows quick, and has a pretty summer appearance behind a wall; but is of little use then as a screen, except to the west; where still it may shade too much (if planted near), as it mounts high. In a dry hungry soil the beech also is very proper; and both bear cutting. The great maple, commonly called the sycamore, is handsome, of quick growth, and being fit to stand the rudest blasts, will protect a garden well in every exposed situation: the wind to be chiefly guarded against as to strength, in most places, being westerly.

The form of a garden may be a square, but an oblong is preferred, and the area rather a level; or if there is any slope it should be southward, a point either to the east or west not much signifying; but not to the north, if it can be avoided, because crops come in late, and plants do not stand the winter so well, in such a situation. A garden with a northern aspect has, however, its advantages, being cooler for some summer productions, as strawberries, spring-sown cauliflowers, &c. and therefore to have a little ground under cultivation so situated is desirable, especially for late succession crops.

The soil that suits general cultivation best is a loam, rather the red than the black; but there are good soils of various colours, and this must be as it happens. The worst soil is a cold heavy clay, and the next a light sand; a moderate clay, however, is better than a light soil, though not so pleasant to work. If the soil is not good, *i. e.* too poor, too strong, or too light, it is to be carefully improved without delay. Let it first, at least, be thoroughly broken and cleaned of all rubbish, to a regular level depth at bottom as well as at top, so as to give full eighteen inches of working mould, if the good soil will admit of it; none that is bad should be thrown up for use, but rather moved away. This rule of bottom levelling is particularly necessary when there is clay be-

low, as it will secretly hold up wet, which should not stand in any part of the garden. (See DRAINING.) When a piece of ground is cleared of roots, weeds, stones, &c. it would be of advantage to have the whole thrown into two-feet-wide trenches, and lie thus as long as conveniently may be. The ground cannot be too well prepared; for when this business is not performed to the bottom at first, it is often neglected, and is not conveniently done afterwards; and so it happens, that barely a spade's depth (or less) is too often thought sufficient to go on with. There is this great advantage of a deep staple, that in the cultivation of it the bottom may be brought to the top every other year, by double trenching; and being thus renewed, less dung will do, and sweeter vegetables be grown. Tap-rooted things, as carrots and parsnips, require a good depth of soil.

The aspect of the wall designed for the best fruits may be full south; or rather inclining to the east, by which it will catch the sun's rays at its rise, the cold-night dews be earlier and more gently dissipated, and the scorching rays of the afternoon summer's sun are sooner off. By thus having the walls of a garden not directly to the four points, the north wall is greatly advantaged by having more sun.

The border next this wall should be of very good earth, about two feet deep, rising a little towards the wall. A free moderate loam, or some fresh maiden soil, not too light, is necessary: and if it is not naturally there, let no trouble be spared to procure it, if it can be had, so as to make all the borders promising good; and in order to this, if manure is necessary, let it rather be that of rotted vegetables, or turf, with a small quantity of wood-ashes; for the roots of fruit-trees should not meet with much dung, at least of horses: that of cows is the best, or that of sheep and hogs will do well rotted, well mixed, &c. being worked in the borders as long as possible before the trees are so planted. Let the holes be some time opened beforehand, that they may be improved by exposure to the atmosphere. Thus due care will be taken, and all things be ready to go about the work of planting properly.

The borders for peaches, &c. cannot be too wide, for in a few years the roots will spread a considerable way: and that they may do it without impediment of rubbish in the walks, and without meeting with a bad soil, is of the greatest consequence to the future health and fruitfulness of the trees.

If a garden is large and square, a second south wall, running down the middle of it, would be very useful; and so, if large and long, a cross wall or two might be adopted, as giving opportunity for the cultivation of more trained fruit-trees, these intersecting walls, ranging east and west, are proper for it (as situated within the ring-fence), furnished with flues, &c.

The best fruit-border being prepared for peaches, nectarines, and apricots, or vines and figs, the trees should take their residence there (if the leaf is falling) about the latter part of October, or as soon after as can be. If the middle of December is past, February is then the time; though gardeners plant all winter, if the weather is open enough at the time to work the ground. March, however, may do, or even the beginning of April.

Wall-trees should not be older than two years from grafting or budding. Much disappointment has been the consequence of planting old trained trees, through their being accustomed (perhaps) to a contrary soil, or by damage done to the roots in taking the trees up; and thus, instead of saving time, it has frequently been lost, being obliged (after years) to be replaced with young ones. But if trained trees are to be made use of, let them be planted as early, and with as full roots as possible, and in a good soil. Except in fine situations as to sun, shelter, and climate, never plant early and late peaches; as the first may be cut off, and the latter not ripen.

The distance to plant should be about 12 inches from the wall: and let apricots, peaches, and nectarines, be twenty feet asunder, more or less, according to the height of the wall; though for the small early sorts fifteen or sixteen feet will do. As the larger apricots, however, grow freely, and do not well endure the knife, they ought to have twenty-five feet allowed them. This is for a wall of nine or ten feet high; if higher, the distance may be less, and if lower, the contrary. This room may seem to some too great; but when trees are planted in too confined a space, after a few years it is troublesome to keep them pruned within bounds: and the cutting they must have makes them run to wood, and thus to become less fruitful. Fig-trees require as much room as the apricot, or rather more; as they grow freely, and are to extend without shortening. Though other trees are best planted in October, the fig should not be till March.

The intermediate spaces between peaches, nectarines, and apricots, may have a vine, a dwarf cherry, or currant or gooseberry tree of the early sorts, as the smooth green and small red, to come in early; and will be improved in the beauty, size, and flavour, of their fruit, by the advantage of situation. But wherever grapes can be expected to ripen, there let a young plant, or cutting, be set, though the space should be confined; for the vine, freely as it shoots, bears the knife well to keep it within bounds. If the wall is high, the cherry or plum may be half-standards; which being after a while kept above, will be more out of the way of the principal trees; though dwarfs may be trained so as not to interfere. Some have planted half-standards of the same kind of fruit as the dwarfs: but whichever mode is adopted, let the intermediate trees be pruned away below in good time, in order to accommodate the principals freely as they mount and extend. The better way however is, when the wall is tolerably covered to extirpate the intermediate trees; as, when large, they impoverish the border, and rob the principals of nutriment. If taken up well in season, and pruned properly, they may be planted elsewhere. Something merely ornamental may occupy the vacancies also, as some double-blossomed fruit-tree, passion-tree, roses, &c. or in a fine situation a pomegranate; any of which may be removed when their room is wanted.

Plums, cherries, and pears, may occupy the other walls; the two former at about fifteen feet, or it may be twenty feet asunder. Cherries, except the morella, will not do well in a full north aspect; but any sort of plum (rather a late one) and summer pears, and also nut-trees, will, if you chuse to train them. There should always be some currants and gooseberries in an east and north

situation, at the distance of eight feet. where they will be easily matted, when ripe, to come in late, as October, November, or perhaps December. Pear trees of free growth are hardly to be kept within tolerable compass on low walls; but if attempted, should have at least thirty feet allowed them. The best sorts of winter pears deserve a southerly wall to ripen them well, and improve them in size and flavour. The gable end of a house is well adapted for a pear-tree, as it affords room, which they require. Apples may do on a wall (and if any on a good wall, let it be the golden-pippin), yet the practice is seldom adopted. The same may be said of mulberries, though they come to bearing much sooner against a wall; but they need not have a south aspect, indeed it has been asserted that they succeed the best in a north one. For furnishing walls chuse trees of moderate wood, young, well rooted, clean, and healthy.

When the planting of a garden is finished, it will be a good way to have a plan of it taken, with the name of every peculiar tree marked on it in their place, to be assured of the sorts when they come to bear. Some have the names of the trees painted on boards, and placed behind them; to which if added the time of ripening, (fixed late enough) it would tend to prevent a premature plucking by visitors, &c.

Here it may be observed, that if any ever-green hedges are desired in or about the garden, yew, box, alaternus, celastrus, phillyrea, and pyracantha, may be kept low, and clipped in form, if so desired; in addition to which, if a few roses were intermixed, it would have a very pretty effect. A deciduous hedge for subdivision, or screen, &c. may be made of elms or limes, setting the larger plants at five feet asunder, and a smaller one between. Or an ordinary fence, or subdivision, may be quickly formed of elder cuttings, stuck in at two feet asunder, which may be kept cut within bounds.

A wide border next the south wall, as was said, is best for the trees; and moreover for the many uses that may be made of it for the smaller early, or late tender esculents, and a few early cauliflowers. For the sake of a pleasant warm walk in spring, to have the south border narrow may be desirable; but on no account let it be less than six feet. Take care that this walk is not sunk too much; and that it have a bottom of good earth, as deep as where the trees are planted. Let the body of gravel be thin, and then the roots of the trees will be admitted to run properly under the walk, and find wholesome nourishment; where, if they were stopped by rubbish, they would be apt to canker, and irrevocably disease the trees.

The number and breadth of the walks must in a measure be determined by the quantity of allotted ground; exceeding in these particulars where there is room. But few and wide walks are better than many and contracted. If the garden is small, one good walk all round is sufficient: and if long and narrow, the cross walks should not be many; six or eight feet walks are not too wide for a moderate-sized garden.

If the ground is laid out in autumn, defer the making of the walks till spring, when the earth will be settled. Gravel laid towards winter would be disturbed by the frost, and the necessary work about the quarters and borders. But whenever made, the garden ought to be brought to an exact level, or slope; then the walks should be stumpt, keeping the tops of the stumps very level (as guides) to the true pitch of the quarters by a light line, made of good hemp, that will bear pulling tight. Proceed to take the earth out of the alleys about eight inches deep, which may be thrown towards the middle of the quarters, to give them a small convexity, which makes them look well.

Rake the bottom of the walk level, and lay the gravel to within two inches of the top of the stumps. The gravel will settle a little, but the walks should always be about three or four inches at their edge, below the quarters, or these will have a flat, and so a mean appearance.

If edgings are to be made, in order to separate between the earth and gravel, especially if of stone, or wood, or box, they should be done first, and they will be a good rule to lay the box by.

If you have plenty of gravel, lay it moderately fine; if little, some small stones, or rubbish of any kind, may be laid in first, and rammed down level with a broad rammer; but do not spare for a little expense, if gravel can be had, as a thick coat of fine gravel will bear relaying, or turning over, to refresh it occasionally in the spring. As the gravel is laid, let the operator neatly rake the larger parts down to the bottom, leaving a fine surface, in a small degree convex, *i. e.* just barely sufficient to throw off wet; walks that lie very high in the middle are unpleasant to both eye and feet, and cannot be so well rolled and kept in order.

When deep walks of gravel are designed, for the sake of the mould dug out of the alleys, it should be forborne, and laid thin, if any trees are intended to be planted near the edge: for if the roots of trees have not a good soil to strike into, when they reach the walks, they will not prosper. In laying gravel very thick it is a good way to do it at two courses; the first of which may be rough, as it comes from the pit, yet still raking the larger parts down, and then ramming or treading it; and the last course should be all of screened materials.

It is best to lay a few yards of gravel only at a time, before ramming or treading: after which it may be necessary to go over it with a fine iron rake, tooth and back; and then a whole walk being finished, it should be repeatedly pressed with a moderately heavy roller; and again soon after the next rain that falls. So will the walks become nicely level and firm, in which their excellence consists.

Grass walks may answer where gravel is scarce; but the latter is so clearly preferable, that except for a little variety in large gardens where there are many walks, they will hardly be made choice of. They are troublesome to keep in order, and if much used are apt to get bare, and out of level, especially when narrow; they are also frequently damp to the feet.

Camomile has been used also to form green or carpet walks, planting it in sets about nine or ten inches asunder; which naturally spreading, the runners are fixed by walking on them, or rolling.

Sand may be adopted for walks, and there is a binding sort of it that does very well; but lay not any of it too thick, as it is the less firm for it. Drift sand is a good substitute for gravel.

Coal-ashes strewed thinly in the alleys are better than nothing, as they at least serve to keep the feet dry and clean. If the garden is of a strong soil, these ashes, when worn down, may be thrown out of the walks, with a little of the earth, and will prove a good manure for the quarters.

Sea-shells make very good walks.

All trees designed to be planted are to be thought of before winter. Those of the wall have been spoken of; and as to standards, they must have a fair depth of good soil to grow in, for it should be remembered, that tree roots in a garden are prevented from running over the surface, as they do in an undisturbed orchard. It is necessary that some caution should be used not to dig the ground too near and too deep about garden trees, lest loosening the roots they should not be able to stand the wind; and because the nearer the surface any root grows, the more and choicer fruit the tree bears.

But the fewer standard trees in a garden the better, as they take up much room, and by their shade prevent the proper growth of vegetables that are near them; so that if a garden is small, there should be no trees except those of the wall. The case is different where there is ample room; and the blossoms of fruit-trees (apples particularly) are so delightful, that if they produced nothing for the palate, there would be a sufficient inducement to plant them for ornament; but let them be dwarf standards in preference to espaliers.

Dwarf-standards occasion less trouble to keep them in order than espaliers, and are generally more productive; for espalier trees are seldom managed well, and thus appear unsightly: at best they are stiff and formal, and obstruct the sight in viewing the quarters of a garden, which, if in order, are worthy of coming under the eye; the violence done to nature, to keep espaliers in form, is commonly paid by disappointment. A writer of repute observes, apples on French paradise stocks, planted at eight or nine feet distance, pruned and kept in an easy manner, make a fine appearance, and produce better fruit, and in greater quantities, than when they are in espaliers. Dutch paradise stocks however last longer, and are altogether superior.

If espaliers are planted, let them be only fruit of the best sorts, and in spacious gardens, where they may have a good length and height allowed them to grow freely; and let it be resolved to do the business neatly. If they may have nothing better than poles or stakes to be trained to, let them at least be straight, and of some equality in size as to height and thickness, smooth, and not too clumsy for the purpose; fix them well in the ground, upright, and about nine inches asunder; at first only four feet from the ground, and raised as the trees advance in height. Apples on paradise stocks best suit for espaliers in small gardens, and pears on quince stocks, as they maintain a small size; but they are apt to decay by the cutting they must have, and so do not prove enduring trees.

Espalier trees should rather be trained to sawed materials properly framed together, smoothed, and painted. But for a year or two they may be fastened to light stakes, when they will have formed a head, to begin to train them for bearing in the neat manner proposed, that is, to slips of deal joined to light oak posts, as trellises. Whether the slips are placed perpendicularly, or longitudinally, seems indifferent. If the longitudinal mode of training is the best approved, strong iron wire may be recommended to run through the posts instead of slips of wood, as it shades less, and is stronger and neater. If upright slips are used, they should be slender, and from six to eight inches distance, according to the greater or less freedom of the natural growth of the tree. The height may be also according to the nature of the tree, from five to six feet, and it will not answer to have them lower. Only a moderate length of trellis (on each hand) need be fixed at first, and so additions made as the tree extends. The posts may be about four feet asunder; the first on each hand being two feet, or a yard, from the stem of the tree.

Apples should be allowed 24 feet, and pears 30; except those grafted on paradise or quince stocks, for which little more than half this distance may answer. Cherries and plums should have about 18 or 20 feet allowed them. Quinces, medlars, mulberries, and filberds, may also be espaliered. The trees should be planted about a yard from the edge, but farther off is better, if the walks lie deep of gravel or poor materials.

The Breda and Brussels apricots have succeeded in espaliers, as also in dwarf and full standards; but the general climate of the place must be mild, and the situation they are planted in must be very sunny and well sheltered. The fruit from standard apricots is very fine, and abundant; but they come not to bearing under several (sometimes 10 or 12) years.

Currants, gooseberries, and raspberries, do well espaliered, as to a production of early and fine fruit.

Trees of a more humble nature, and shrubs, next occupy attention in furnishing a garden. Currants and gooseberries (as bushes) should be planted three feet from the edge, and full six feet asunder. Some of these very useful shrubs should grow in every aspect of the garden, in order to have a succession of their fruits, as long as may be. Those who choose to plant whole quarters of currants and gooseberries ought to do it at six feet asunder in the rows, and the rows eight feet from one another.

Raspberries may be set in plantations, in rows five feet asunder, allowing three feet between the plants. These shrubs are always best by themselves, as otherwise their suckers over-run the quarters. Between rows of raspberries planted at the above distance, coleworts, early cabbages, cauliflowers, and lettuces, may be set, or spinach sowed in drills; the raspberries having had their pruning and dressing early in autumn, for the purpose. Every year a little short manure, dug in close about the roots, (and deeper as the plantation gets older) will insure fine fruit. Raspberries are not very nice as to soil and situation; but the twice-bearing sort should have a dry soil and warm birth to forward the crops, that the last may be in time. See that the plants to be set have good brushy roots, and two or three eyes to each root near the stems, for the next year's bearing. The smooth-wooded, or cane rasp, is to be preferred for a principal crop. The large, white, or Antwerp, is also good.

Strawberries may be planted at the edges of borders and quarters, either in single or double rows (rather the latter) for the convenience of gathering, and for orna-

ment; but the common and best way is, in four-feet beds, with eighteen-inch and two-feet alleys, on which beds may be five rows of the wood and alpine, four of the scarlet and pine-apple, three of the Carolina, and two of the Chili; setting the plants at the same distance in the rows, as the rows are from one another in what is called the quincunx order, that is, like the five of cards. In a good, cool, loamy soil, which suits them best, a little more distance may be allowed the first four sorts; and in a quite dry light soil, somewhat less, that they may shade one another the better from drought.

The best situation for strawberries is an open and sunny one, as thus they bear more, and finer-flavoured fruit. Some of the scarlets should be planted under warm walls to come early. The woods bear shade as natural to them, and the alpines do tolerably well in it. As lengthening the season of fruit is a desirable circumstance, for these three sorts (at least) the situation should be various.

The most proper time for planting the strawberry is the first moist weather in September, (or even earlier) that they may be established in the ground before winter, and they will bear the better the first year. Frost is apt to throw up late-planted ones, and injures, if not destroys them. Those planted in spring often suffer from drought, and bear very little thr first year, except the alpines. Choose forward runners for planting, and let them be from beds in full bearing, that is, of two or three years old; for plants from old beds are not so fruitful. Take care also they come from beds producing fruit good in its kind, and true as to sort: much depends on this. Press the mould to the roots, give them a watering, and again once or twice, if the weather proves dry. Some gardeners let them run over the beds, which in a dry light soil may be proper; but in this case, a greater distance should be allowed them at planting.

If the alpine sort is planted on a warm border, eighteen inches asunder, and suffered to spread, the first runners will fruit the same year, and sometimes this prolific strawberry bears till November.

Fresh plantations of strawberries should be made every fourth year, though in a good soil and with good management they will continue longer: so that where they are suffered to run, the plants being frequently renewed, and old ones removed, beds have borne tolerably for ten years. Some gardeners insist that this spreading mode is the best way of cultivating the strawberry. In a dry season, such full-covered beds have the advantage, but in a wet one the fruit is apt to rot, though still in such a season it is cleaner than from plants growing in an open way; but this carries the appearance of neglected culture. The method of keeping them in detached plants produces the largest and best-ripened fruit, and on the whole is preferable; for which practice there cannot be a stronger argument, than that those follow it who cultivate the strawberry for sale.

The watering of strawberries should not be neglected, doing it almost daily when in flower, and setting their fruit, if the weather proves dry, particularly to those under a warm wall; but this is not to be continued when the fruit is nearly ripe, which would spoil the flavour, and dispose them to decay.

Flowering shrubs may be dispersed about, and herbaceous perennial flowers; but plant them not too near the edge, lest they hang over the walks. The bulbous sorts may however, be within six inches, especially crocuses and snowdrops

Asparagus and artichokes should be thought of, but they take up much room, and in small gardens may therefore be left out. It will be of little use to have less than 50 or 60 feet of asparagus beds, as there would be so few heads to cut at a time; and artichokes must be planted wide, or they will not grow large and fleshy, in which their merit consists.

Let not pot-herbs be forgotten, but provide a general herbary in that part of the garden which is warmest, and best-shaded, for these are tender plants.

Having spoken of stationary things, the routine of the seasons must dictate the rest; and the inclinations of the palate will refresh the memory to take care of providing the most necessary and agreeable esculents for dressing, and raw salads.

Perennial flowers have been mentioned; but let fancy direct as many annuals and biennials to be cultivated, as room can conveniently be found for, that the garden may be, as much as possible. ornamented.

In furnishing a garden with shrubs and flowers, respect should be had to their usual height, their bulk, colour, and season, that the mixture may be properly varied, harmonious to the eye, and come in regular succession. The latter part of the year is seldom provided for so well as it might be; late flowers should be set in warm situations, as their proper place. In the most dreary months, by judicious planting, evergreens in their neat and cheerful " winter liveries," may be viewed from our windows, and serve instead of flowers.

Those who garden upon a large scale, should take care to have every thing proper and convenient liberally provided. Let there be a well-situated place for hot-beds, with some building as a tool-house, and (if dry) for keeping bulbs, seeds, and herbs. Those also who garden even upon a small scale will do well to have every needful implement. It is the way to save time and labour, and have work done well.

If water can be introduced, and kept clean with verdant banks around it, it would be found very useful where a garden is large; but let it be as near the centre as possible, as the most convenient situation. It should be fed from a pond in preference to a spring.

Mixed gardening, as comprehending the useful with the sweet, the profitable with the pleasant, has been the subject hitherto; but if the flower garden and the kitchen garden are to be distinct, the case is altered; not so much indeed but that still the kitchen garden should be adorned with a sprinkling of the more ordinary decorations, to skirt the quarters, chiefly those of the most powerful sweet scents, as roses, sweet-briars, and honey-suckles, wall-flowers, stocks, pinks, minionet, &c. in order to counteract the coarser effluvia of vegetables, or of dead leaves, which, however, should not be suffered to annoy.

The flower garden, properly so called, should be rather small than large; and if a seperate portion of ground is appropriated for this, only the choisest flowers should be introduced, and no trouble spared to cultivate them in the best manner. The beds of this garden should be narrow, and consequently the walks numerous; and not more than one-half or two-thirds the width of the beds, except one

principal walk, all round, which may be a little wider. The gravel, or whatever walks are made of, should lie about four inches below the edge. The beds for tulips, hyacinths, anemonies, ranunculuses, &c. may be three and a half or four feet wide, and those for single flowers the same, or only two and a half feet wide in the borders, which was the most usual breadth in the old flower gardens. Let the beds lie rather rounded in the middle, but the walks flat

Figured parterres have got out of fashion, as a taste for open and extensive gardening has prevailed; but when the beds are not too fanciful, but regular in their shapes, and chiefly at right angles, after the Chinese manner, an assemblage of all sorts of flowers, in a fancy spot of about 60 feet square, is a delightful home scource of pleasure, worthy of pursuit. There should be neat edgings of box to these beds, or rather of neat inch-boards, painted lead colour, to keep up the mould. Be sure to keep the box from the very first, as soon as rooted, and always after, as low as possible: clip it twice a year, April and July.

Landscape or *picturesque gardening*, is so much the work of fancy, and so much depends upon the situation, or what the celebrated Mr. Brown used to call the capability of the place, that no precise rules can be laid down concerning it. All, therefore, that can be expected, is a few lose hints, on which the man of taste may improve according to circumstances.

Those, however, who would do much in landscape gardening, should not be forward to trust their own taste altogether. In this business there is no making experiments, but all should be executed, as much as possible, upon certainty. There is a variety of works and decorations in extensive gardening, which injudiciously introduced, might create a wasteful expense. This is an error that ought to be avoided, and most probably would be by those who have been in the habit of studying nature, and the powers of art as her submissive handmaid.

The pleasure we seek in laying out gardens, is now justly founded upon the principles of concealed art, which appears like nature; but still, whether ingenious contrivances, and decorations, (altogether artificial,) should be so entirely laid aside as they are, may deserve to be considered. Gardens were formerly loaded with statues, and great improprieties were committed in placing them, as Neptune in a grove, and Vulcan at a fountain, large figures in small gardens, and small in large, &c. but perhaps the works of the statuary might still be introduced if well excuted, and in proper places. A terrace as a boundary, is now seldom formed; but in some situations, such an eminence might in several respects be agreeable.

If trees are planted injudiciously, the error is a trifle; but if cut down so, the consequence is serious, and has often been sorely lamented; extirpation should therefore be well thought of before it is executed; especially trees about houses, for many dwellings have been thus too hastily exposed, and deprived of comfortable shelter and shade. And why should a taste have prevailed for so sudden a transition, as no sooner out of the house than to arrive in the open country; or why should an extensive garden be thrown as much as possible into a single view, when meeting with new objects in our walks is so agreeable?

Hilly spots that are in view of the house should be planted with firs, as fine-looking trees, and very hardy. Beech does well on high ground, especially if chalky. In low ground, not to mention alders, and that tribe, the birch, and even the oak, should not be forgotten, where the wet does not long stand.

About the house some shady walks ought always be provided, by thick planting, if not of trees, yet of flowering shrubs, and evergreens, of which the laurel will be found the most useful. If there is good room, single trees of the fir kind, at due distances, are admirable ornaments about a house, and clumps of shrubs all of the same kind have a good effect.

Those who have much space of ground to decorate, do well to plant trees and shrubs of every kind, as enlarging the sources of amusement, and affording opportunities for observation; but if the allotment of ground for this purpose is contracted, then, of course, those only should be planted, which by their neat foliage, natural symmetry, and gay flowers, may be truly esteemed ornamental. They should be such as strike the eye of persons in general, though they have nothing of singularity to engage the attention of the curious in plants. It too often happens, that good old sorts of trees, shrubs and flowers, are excluded for new ones; but if the latter are not more elegant, and generally pleasing, the practice is surely not a wise one: in ornamental gardening, great care should be taken, in the choice of what is really handsome, that nothing dull or rambling be introduced.

The walks should always be wide, some inclining to serpentine, and contrived as much as possible upon a level, as walking up and down hills can hardly be called pleasure. That they may be extensive, they should skirt the grounds, and seldom go across them. In small pleasure-grounds the edges of the walks should be regularly planted with flowers, and long ones occasionally so, or with the most dwarf shrubs; and neat sheltered compartments of flowers, (every now and then to be met with) have a pretty effect. If the walks are extended to distant plantations of forest-trees, every opportunity should be taken, to introduce something of the herbaceous flowery kind, which will prove the more pleasing, as found in unexpected situations. The outer walk of pleasure grounds and plantations, should every now and then break into open views of the country, and to parts of the internal space, made pleasing, if not striking, by some work of art, or decoration of nature.

Water should only be introduced where it will run itself clear, or may be easily kept so, as also in full sight; and some fall of it should be contrived, (if possble) for the sake of giving it motion and sound, because a lively scene of this element is always much more pleasant than a dead one. Every spring of water should be made the most of, and though fountains, &c. are out of fashion, something of this kind is agreeable enough. Near some pieces of water, as a cool retreat, it is desirable that there should be something of the summer-house kind; and why not the simple rustic arbour, embowered with the woodbine, the sweetbriar, the jessamine, and the rose? Pole arbours are tied well together with burk or ozier twigs.

Before the design of a rural and extensive garden is put in execution, it ought to be considered, or anticipated, what it will be in twenty or thirty years time; for it of-

ten happens that a design which looks handsome when first planted, and in good proportion, becomes so small and ridiculous in process of time, that there is a necessity either to alter it, or destroy it entirely, and so plant it anew. To proportion the breath of walks, the size of carpets, casting and levelling of grounds, parterres, &c.; the disposal of fountains, statues, vases, dials, and other decorations of magnificience to most advantage, requires a particular address, says Mr. Evelyn, or to speak more emphatically, a prophetic eye; and though the taste is not what it was in Mr. Evelyn's time, yet, perhaps, the only difference is that more skill is requisite.

Landscape gardening depends much on the form of the ground, and therefore to shape that is the first object, Some situations may not need it, and perhaps a little alteration may produce a happy effect in others; therefore great alterations should not be attempted without manifest advantages, as either levelling, or raising ground, is a heavier business than is commonly supposed, both as to time and expense.

Too much plane is to be guarded against; and when it abounds, the eye should be relieved by clumps, or some other agreeable object. Hollows are not easily filled; and eminences mostly are advantageous, in the formation of picturesque scenes, in which the general principle of ornamental gardening consists. This idea has been pressed so far, that it is contended, a gardener should be a studier of landscape paintings. But without an immediate view to pictures, no doubt, grounds may be laid out in a way sufficiently picturesque. That view may be very agreeable in nature, which would not be so in a picture, and the contrary.

Picturesque gardening is effected by a number of means which a true rural genius, and the study of examples, only can produce. These examples may be pictures, but the better instructors will be scenes in nature; and the proper grouping of trees, according to their mode of growth, shades of green, and appearance in autumn, will effect a great deal.

To plant picturesquely, a knowledge of the characteristic differences of trees and shrubs, is evidently a principle qualification. Some trees spread their branches wide, others grow spiral, and some conical: some have a close foliage, othees an open one; and some form regular, others irregular heads, the branches and leaves of which may grow erect, level, or pendant.

The mode of growth in trees, as quick or slow, the time of leafing, and shedding leaf, with the colour of the bark, are all circumstances of consideration in order to produce striking contrasts, and happy assemblages, in the way of ornamental gardening.

To range the shrubs and small trees, so that they mutually set off the beauties, and conceal the blemishes, of each other; to aim at no effects which depend on a nicety for their success, and which the soil, the exposure, or the season of the day, may destroy; to attend more to the groupes than to the individuals; and to consider the whole as a plantation, not as a collection of plants; are the best general rules which can be given concerning them.

In considering the subjects of gardening, ground and wood first present themselves; and water next; which, though not absolutely necessary to a beautiful composition, yet occurs so often, and is so capital a feature, that it is always regretted when wanting; and no large place can be supposed, a little spot can hardly be imagined, in which it may not be agreeable. It accommodates itself to every situation, is the most interesting object in a landscape, and the happiest circumstance in a retired recess: captivates the eye at a distance, invites approach, and is delightful when near: it refreshes an open exposure, it animates a shade, cheers the dreariness of a waste, and enriches the most crowded view. In form, in style, and in extent, it may be made equal to the greatest compositions, or adapted to the least: it may spread in a calm expanse to sooth the tranquility of a spaceful scene; or hurrying along a devious course, add splendour to a gay, and extravagance to a romantic situation. So various are the characters which water can assume, that there is scarcely an idea in which it may not concur, or an impression which it cannot enforce.

On the works of art in gardening, the following passage is pertinent: "Art was carried to excess, when ground, wood, and water, were reduced to mathematical figure, and similarity and order were preferred to freedom and variety. These mischiefs, however, were occasioned, not by the use, but the perversion of art; it excluded, instead of improving upon nature, and thereby destroyed the very end it was called in to promote. Architecture requires symmetry, the objects of nature freedom; and the properties of the one, cannot with justice be transferred to the other. But if by the term art no more is meant than merely design, the dispute is at an end; choice, arrangement, composition, improvement, and preservation, are so many symptoms of art, which may occasionally appear in several parts of a plantation, but ought to be displayed without reserve near the house: nothing there should seem neglected; it is a scene of the most cultivated nature, it ought to be enriched, it ought to be adorned; and design may be avowed in the plan, and even in the execution. Regularity is not excluded: a capital structure may extend its influence beyond its walls; but this power should be exercised only over its immediate apendages. Works of sculpture are not, like buildings, objects familiar in scenes of cultivated nature; but vases, statues, and termini, are usual appendages to a considerable edifice: as such, they may attend the mansion, and trespass a little upon the garden, provided they are not carried so far into it as to lose their connection with the structure."

The cultivation of a garden.—The first object with a view to produce should be, to keep the ground in such a state as will enable it to produce good crops. Good vegetables cannot be had without good manure. Yet raw unwrought dung is not good for a garden. The most economical plan therefore, that can be pursued, is for the first year to make good hot-beds of your dung, and spread it out upon the quarters, and dig it in in autumn and winter. You by this means have a double produce, and the dung is the better.

Dung, however, used in great quantities, and lying in lumps, breeds worms, grubs, and other insects, and causes plants to grow too rampant and rank-flavoured. Carrots it cankers, and it disagrees with many things. On these accounts some persons have been induced to dress their gardens only with rich fresh earth; which, if they do not overcrop, will do very well, being accom-

panied with good tillage: which alone is of much use, and is essential to due cultivation. The method just recommended, of letting dung lie in the state of a hotbed for a time, is good, as it abates the rankness of it.

If the ground is in proper heart, every spot may be contrived to be constantly and successfully cropped. The common gardeners about London, who give high rents for their land, contrive (manuring well) a succession of crops, one under another, very dexterously; and this sort of conduct should be imitated by private persons. Thus a little spot, in skilful and industrious hands, will be much more productive than a greater under contrary management: but when hard worked, the soil will not do without a good deal of manure.

In the occupation of ground, the change of crops will be proper, as each sort of plant draws a somewhat different nourishment: so that after a full crop of one thing, one of another kind may often be immediately sown; but it should be contrived that a wide crop may follow a close one, and contrariwise.

Close crops, as onions, leeks, carrots, &c. are conveniently and neatly cultivated in beds of from four to five feet width, with alleys of from a foot to eighteen inches between them.

The seasons proper for furnishing the ground with every particular vegetable, should be well attended to, that each may be obtained as early as its nature will permit; and of the seeds and plants we use, care must be taken to procure the best of the kind, lest after all the trouble of cultivation, disappointment as to quality should ensue.

Seeds and plants should be adapted as much as possible to the soil and situation which best suit them; for in the same garden some difference will be found, not only as to sun and shelter, but the earth; as some will be richer, some poorer, some deeper, some shallower, and some perhaps, heavier, some lighter, in due attention to which, advantage is to be reaped.

The thinning of seedling crops should be done in time, before the young plants have drawn one another up too much. All plants grow stronger, and ripen better, when the air circulates freely round them, and the sun is not prevented from an immediate influence; an attention to which should be paid from the first appearance of plants breaking ground.

In the pricking and planting out of crops, be sure to do it as early as may be; let every thing be regular, (not sparing to use the line) allowing always room enough for this work; and being thus treated, vegetables will come forwarded, larger, and of a superior flavour. These advantages are seen in all things, but in letuces particularly, which have not half the room allowed them they should have. Over-cropping robs the ground of strength to no purpose, except increasing the dunghill; it makes it also inconvenient to weed, rake, clean up, which in a private garden, at least, it is proper frequently to do.

Shading of new-planted things, particularly flowers, is of much benefit, and that in proportion as the season is sunny, as neglecting this business has frequently proved: as a little water in a cloudy time does plants much good, so when shaded.

Strawberries and cauliflowers are generally watered in a dry season; that is, the strawberries when in bloom, in order to set the fruit, and the cauliflowers when they show fruit, in order to swell the head. In a light soil, this ought particularly to be done. In very dry weather, asparagus seedlings, early turnips, carrots, radishes, and small salads, will need watering. Slips, cuttings, and layers of any kind, will need water. Pots of flowers must have it frequently.

When watering is undertaken, let it be a complete business; *i. e.* to the bottom and extent of the roots; as much as may be. The wetting only the surface of the ground is of little use, and of some certain harm, as it binds and cracks the earth, and so excludes the benefit of showers, dews, air and sun, from entering the soil, and benefiting the roots as they otherwise would do. Wetting the surface of the ground, however, in a summer's evening, makes a cool atmosphere; a dew is formed, which pervades the leaves, and helps to fill their exhausted vessels.

Watering the roots of wall-trees, (if dry weather) when the fruit is setting, is by some thought necessary. The best way to do this effectually, is to make a few holes at some distance from the three with a smooth sharp-pointed stake, the better to let the water down; but this may wound the roots; and should only be practised in a light soil, and very dry season. To young trees only it can however be of use, for the roots of old ones run far and wide; and it is the small fibres of these distant roots, on which the tree chiefly depends for food. Vines should have no water till they are off blossom, (July) and the fruit as big as large pins' heads; and then if the season is very hot and dry, watering the roots twice a week will help the fruit to swell.

As watering is apt to make ground hide-bound and unsightly, let the surface be occasionally stirred and raked, which will make future waterings enter the ground the better; when the ground is hard on the top, the water runs away from its proper place, and half the labour is lost. Many things are impatient of being kept wet about the shanks, and therefore watering should be generally at a little distance.

The quality of water used for refreshing plants is a material thing, and is very various in its nature, according to the peculiar earths and mineral substances that it passes through. Rain water is by far the best, as appears by the verdure and vivacity it gives.

Pond water is next in fitness, and river water follows. Well water is of least account, though local circumstances occasion its use the most. So that in forming a judgment concerning watering, it is not simply to be considered, whether plants should be watered; but whether with well-water, and that too from a pump. Pump-water, if used directly, is so cold in summer, that it is found prejudicial to plants: and great cold so contracts their vessels, that they perform their proper offices with difficulty, and become diseased.*

The management of a garden, as somewhat distinct from the cultivation of it, is an object of consequence; that is, to keep it in such order, that it may not fail in those general impressions of pleasure it is capable of affording, when things are shown in their best manner. A garden may be cultivated so as to be profitable; and yet not conducted so as to be agreeable to walk in, which in a private garden is a circumstance surely to be lamented. The proper appearance of a well managed one is express-

ed by the word neat. Let all be done that can be in order to it.

To be neat, weeding must be industriously followed up, and all litter that is made in working, quickly carried off. The ground also should be frequently stirred and raked between crops, and about the borders, to give all a fresh appearance. There is a pleasantness to the eye in the new-broken earth: and when there are no flowers left in the borders, this gives an air of culture, and is always agreeable. The observation is particularly meant to apply in autumn, that the garden may not become dreary too soon, and so bring on winter before its time. An asparagus-fork is expeditious and useful in this case; but it must be slightly used, lest it disturb the roots of plants too much. Vegetables should not be suffered to rock themselves by wind, so as to form holes round their stems, but be well earthed up or otherwise supported.

Trees and shrubs should be constantly freed from suckers and dangling shoots, and wall trees ought to be regularly kept in order. Grass plats and walks should have their edges occasionally cut, and be mowed as often as there is the least hold for the scythe, for they lose much of their beauty, when the grass gets long; leaves should not be suffered to remain on them, as it stains the grass; and worm-casts should be cleared away. Edgings of all sorts should be kept in good order, as having a singularly neat effect in the appearance of a garden. The dead edgings will sometimes, and the live edgings often, want putting to rights; either cutting, clipping, or making up complete. Where there are no edgings, or but weak ones, let the earth bordering on the walks be kept firm, and now and then worked up by a line in moist weather, beating it smooth with the spade.

Some fruits may need support, by tying their weak branches when they get heavy, to stakes, &c. Rows of raspberries and beans are kept neatly up in their lines, by putting in here and there a stake, and using packthread lengthwise; and thus will they bear better, and be more conveniently gathered. Strawberries of fine heavy sorts, will be preserved from getting dirty and rotten, by tying their stems to little sticks; by this practice the fruit also g ts better ripened, and of a finer flavour. Some persons lay tiles, or moss round the plants, when the fruit is half-grown; but this is not, generally, so well, only it has the advantage in keeping the ground cooler in a hot season. The first and finest scarlets best deserve this trouble.

Flowers should be frequently tied up, and dead and dangling parts trimmed off. Some of them cannot do without support, and many sorts are made more secure and beautiful by proper ties. If this business is neglected, a heavy rain or strong wind may come, and lay all prostrate, especially about the equinoctial seasons; but weakness or their own weight, will often bring flowers down.

The sticks used for flowers, should be of smooth wood, as hazel or sallow, or of neat painted slips of deal, with or without an ornamental head; white is the best colour, on account of its contrast with the leaves.

Decaying flowers should be timely trimmed or removed, and perennials should be regularly freed from the parts running to seed, (except so much as may be wanted) as the production of seeds weakens the root much; sometimes even causing death, and thus many curious perennials have been lost; especially the first year of planting them. To preserve any particular sort therefore, let the stems be cut down as soon as the flowers appear to be going off, or to secure the root in strength, let them not flower at all the first year.

Of Propagation.—Plants are propagated by seeds, suckers, slips, off-sets, divisions, cuttings, layers, and grafts.

By seed is the most general method of propagation, and plants raised any other way are seldom so fine. Those plants from seed which have never been removed, are commonly handsomer, and come forwarder, than those that have been transplanted, provided they were sown in a proper soil and situation.

Commonly speaking, new seed is to be preferred to old, as growing the more luxuriantly, and coming up the surer and quicker. This circumstance induces some private persons to save their own seed that they may not be deceived in buying old for new seed; a trick of trade, it is to be hoped, not practised by every seedsman. Yet a little mixture of old seed is sometimes proper, because the new is perhaps cut off, and the old saved, by being a day or two later in coming up.

If old seed is knowingly sown, some allowance in point of time must be made. Peas and beans of two years old, are by some preferred to new, as not running so much to straw. The same may be said of cucumbers and melons.

As to the age of seeds, at which they may be sown and germinate, it is uncertain, and depends very much how they are preserved. Seeds kept from the air and moisture by being buried deep in the ground will continue a great many years without corruption. Peas and beans will germinate very well at seven years of age; but the seeds of lettuces, onions, kidney-beans, and some others, are not to be depended upon after a year or two; and though generally speaking the smaller seeds are of the least duration, yet their maintenance of vegetative power depends much upon the texture of the seed, with respect to its coat, and the oil it contains, &c.

The saving of seed by private gardeners, is hardly to be recommended. Things running to seed give a garden a rude appearance, often occupying ground that is wanted, and might be used to better purpose: and the case often is, that seeding plants (in private gardens) are neglected in some measure, or destroyed by birds, and come to little at last. Perhaps they are not saved from proper plants. It is a particular business to raise seeds for sale, and, generally, they are best had from those whose province it is to deal in them.

Seeds should be saved from fine forward plants, secured from rocking about when they get tall; guard them against birds, gather them regularly as they ripen, lest they shed and are lost, and keep them dry. Flowers it may be proper to save the seed of, and it is little trouble. It should be a rule for flower-seeds in general to be fresh from year to year; though if kept dry, and from much air, many sorts will grow that are older: curious flower-seeds are kept well in phials: others may be in small drawers, and some hung up, or kept on shelves in their pods.

Seeds may be forwarded for sowing by various ways of procuring a germination before they are put into the

ground. In summer it has been usual to steep both broad and kidney beans in soft water, about twenty-four hours, to forward their growth, and to ascertain their vitality. If the ground is very dry, when these seeds are committed to it, either steeped or not, it is a good way to make drills or trenches to plant them in, watering them well first, and then pressing the seed in a little. Any sort of the broad beans, or even peas, may be forwarded, when ground is not for the present ready, by laying them in damp mould, in a garden-pot; or otherwise, a layer of earth, and a layer of seeds, &c. and they may be put into drills or trenches, with care, when the radicle has got some length, the mould being light, and the work finished by a gentle watering.

The smaller seeds, as carrots, &c. may be prepared for sowing, by simply mixing them in a little moist sand, or fine earth, taking care that they do not lie longer than the usual time of their beginning to sprout; but this practice need only be adopted for seeds that are long in coming up, and then there is some advantage in having them to sow in a state ready to strike immediately on fresh-dug earth.

The season for committing seeds to the ground, should be as early as the nature of the plant to be cultivated will bear; for the forward productions which come without forcing, are the best as to size, flavour, and fruitfulness, if they meet with no material check from weather. It is the proper ambition of gardeners also, to have some of the first of each kind of vegetables and fruits, and thus to vie with others.

Let this direction for early sowing be understood, not only of spring, but autumn crops; that the plants designed for winter use, or to stand for spring, may be strong, and well established in the ground: though for those designed for spring, it is advisable to have two or three different sowings; for lettuces, as an instance, that are forward, will sometimes fail when backward plants shall do well.

To be sure of a crop, and in some things a succession of crops, various sowings should be made through the year, at all times that are not too unnatural as to season; for it is an object in gardening, not only to have early and late productions, but never to be without what may be produced. Every sowing that is made, the early ones in particular, should be noticed in time, whether it is likely to succeed, that the work may be repeated. But a little caution is necessary, that this business be not overdone; for though there may seem to be a sufficient distance of time in sowing for succession crops, yet they tread sometimes upon the heels of one another so fast as to occasion a superfluity. This is often the case in peas and beans, in the height of summer, and especially if a hot season: this caution is the more necessary, where there is no ground to spare, or but few hands to cultivate it; labour with discretion.

Sowings should be generally performed on fresh dug or stirred ground. The digging should therefore be done as near the time designed to sow as can be. If the ground turns up raw, or wet, as early in the spring it is apt to do, a little time must be allowed it to dry, and so also if rain falls first. In this case, seed should be sown as soon as ever the ground may be trampled on not to hang to the feet; for when the soil is too wet, it binds and does harm, especially in heavy ground. It is to be observed, however, that sowing in drills or on beds that are not to be trampled, the moisture of the ground is rather an advantage, provided in the last case, that the ground will admit a rake, and the soil is not too wet to drop somewhat loosely about the seeds.

The proper depth at which seeds should be sown is to be carefully observed; if too deep, they will either rot, or not thrive well; and if too shallow, they are liable to be injuriously affected by frost, wind, drought, or birds; but of the two rather too shallow, than too deep, is best, and this we are taught by nature, whose sowings are mostly superficial.

The smaller the seed the finer should the soil be, and the less also the covering; so that while some, as the seed of celery, is to be but barely covered, others, as peas and beans, may have a depth of two, three, or four inches. But some regard is to be had to the season and soil; in a warm season, and light soil, sow deeper, and the contrary shallower.

The quantity of seed sown is a thing to be attended to with some exactness. Small seeds go a great way, and require a careful hand to distribute them; for though sowing a little too much is a trifle as to the value of seeds, yet to have them come up crowding thick is an evil. To sow evenly as to quantity, is an object of practice worthy of care, as it secures a better crop, and more easily managed in the thinning. If the seed is suspected, sow thicker; poor land will require more seed than rich.

It is not generally advisable to sow several sorts of seed on the same spot, as some persons are accustomed to do. The gardeners about London follow the practice; as profit is their great object, and not neatness or propriety. On the same piece they sow radishes, lettuces, and carrots; the radishes are drawn young for the table, the lettuces to plant out, and a sufficient crop of carrots is left, for carrots should not be very near to grow large: this is as reasonable a combination as any that is made; but still, if not short of ground, each kind separate will be found best. In defence of this mode of culture, it is said, if one crop fails, the others may do, and there is no loss of ground or time; and if all succeed they do very well. Some little things of this sort, indeed, may well be done; as a piece of ground new-planted with horse-radish may be top-cropped with radishes or spinach, &c. A thin crop of onions upon new asparagus-beds, may also take place, drawing them while young from about the plants.

All seeds come up best when moderately pressed with the earth; for if they lie too lightly in contact with it, cold and drought more easily affect them; and when once seeds begin to germinate, they are impatient of both. To trample seeds in is on the whole better than any other pressure. This done, lay all immediately and neatly level with a wide rake, drawing off stones, &c. but do it lightly, to avoid driving in the teeth of the rake, which would remove the seed, and make it come up irregularly.

Propagation by suckers is a mode of culture rather peculiar to trees and shrubs. The things to be observed in this business are, to take them up with some care from the mother plant, so as not to injure its root, nor the sucker's own root, by pulling it up without properly

loosening it first. The earth should be moved aside by a trowel, and then the sucker cut off by a knife, and not with a spade, as is common. Of those hardy things of which there is plenty, this rough way does not signify much as to the sucker, but it may injure the root too much that it comes from. Wherever a root appears barked, the part below should be cut off. If it is desired to succeed well, in propagating by suckers, consider that all young roots are tender: let them be trimmed to form, and planted immediately; or at least let them be covered with earth or laid by the heels, as it is called. Suckers with poor roots, must have their heads reduced the more.

Propagation by slips is of two sorts, either from the root, or stem; and several sorts of flowers and herbs are increased this way. When from the roots, if the whole is not taken up, move the earth carefully aside, and slip off by a pressure of the thumb and finger, and be cautious of hurting the fibres of the slips, planting with fine and good mould about them. Take off slips from the stem carefully by the push of the thumb, and not too many from the same plant, as it is apt to injure the place by tearing off some of the wood. Slips from the stem are to be considered as cuttings, and treated accordingly. They take more certainly, and make better roots, than cuttings.

Offset is a term sometimes applied to slips from fibrous roots; but more properly so from bulbous roots, which put forth many offsets. These are slipped away at the time they are taken up for removal or replanting, and commonly take two or three years before they bear flowers: dispose of them therefore in a nursery, where they may remain undisturbed till they come to a flowering state. Keep them however clean from weeds, and stir the ground a little.

Division of the roots is a way of propagating many sorts of plants. To this end, of course, they must be taken up, and then either carefully pulled, or cut asunder with a sharp instrument, as the case may require. It is not safe, however, to divide such roots into very small pieces, especially if cut, as then they are apt to die; but leave them of a size sufficient not barely to secure life, but to form immediately a handsome head. The general season for thus splitting fibrous-rooted plants is October, but it may be done early in the spring, as February or March.

Cuttings of a variety of woody plants will grow, and many trees and shrubs are propagated this way; but their sap must be of a watery nature, as those plants that are gummy will not strike (or rarely), though ever so much care is bestowed, or time allowed them. The texture of the wood of cuttings must be somewhat soft, as hard-wooded ones will not grow. Cuttings should be rather short than long, and kept steady in the ground. If they are planted where there is any likelihood of their being disturbed, they may be tied to a stick well fastened in the earth.

The season for setting slips and cuttings is for some things summer, as wall-flowers and myrtles; and for most from October to March; but, in general, the sooner the better. It has however been said, that spring is the best time for all, and that the sap should be in motion first. This is at least true of some things: as cuttings of the vitex, or chaste-tree (though hardy), are found to do best in spring; and all cuttings from plants of a delicate nature do so.

Cuttings should be of well ripened wood, and have the earth pressed to them the whole length they are in the ground; *i. e.* from four to six inches. Cut them with a sharp knife slopewise, and plant in a good soil, and in a situation where they have only the morning sun; and keep them cool (not wet) by occasional watering in dry weather.

Laying of branches is a mode of propagation that may be adopted for almost all forest-trees, and several sorts of fruit-trees and shrubs; *i. e.* all that will grow from cuttings, and many that will not. Layers are less rampant, and more fruitful than suckers; and for those who are curious, and find a seminal variety of any tree or shrub that is remarkably different from the original, the only way to have it preserved genuine is to convert it into a stool (by cutting down), and raising plants by layers. They are made of the lower branches of the plant, and must be young and pliable, to bend down without breaking to the depth of four, five, or six inches in the ground, as the soil is light or heavy, at which they must be held securely by good pegs, and if they cannot be brought down sufficiently deep, some earth may be raised up to them.

Let the ground about layers be kept cool by occasional waterings, and laying some moss, turf, litter, or rather small pebbles about them, which will not harbour insects. The part out of ground may be supported erectly by a tie to a stick. It is a good way to slit, with a sharp knife, the part at the peg, as in carnation layers, a little more than an inch; and some prick a few holes about the part, at a joint, with a blunt awl, to help the layer to strike root. For the harder woods, some gardeners make several slits, or chips, in the part layered in the earth, and bind the layer rather tight, just above it, with pliant wire; and soft-wooded layers are sometimes twisted to crack the bark, in order to help the part to strike quickly. Generally layers should be shortened to six or eight inches above the ground; or do it to two eyes, be it more or less above ground.

Where there are no branches low enough to be brought into the ground, and it is not thought good to head down for the production of low shoots or suckers, plants may be layered by fixing a broken pot, or a box, with a slit in the side, to the height necessary to lay in a branch. A branch also, if long enough, may be thrust through the hole of a garden-pot upwards, then filled with earth, and supported by some contrivance, and shaded by some means, and in both cases water frequently. Take care not to injure the buds in drawing through the hole of the pot. By this contrivance rooted plants being procured in pots, may be turned out with the earth about their roots undisturbed. A branch of a vine thus layered in November, may be next year cut off, when the fruit is ripe, brought in the pot to table, and afterwards planted out. For propagation of fruit-trees by grafting, see that article. See also GREENHOUSE, HOT-BEDS, NURSERY, ORCHARD, PLANTING, PRUNING, VEGETABLES, &c.

GARNET, granatus, in natural history, a very beautiful gem of a red colour, with an admixture of bluish.

When pure and free from blemishes, it is little inferior, in appearance, to the oriental ruby, though only of a middle degree of hardness between the sapphire and common crystal. It is found of various sizes, from that of a pin's head to an inch in diameter.

Among our lapidaries and jewellers, genuine garnets are known by different names, according to their different degrees of colour. 1. The garnet, simply so called, is the finest and most valuable kind, being of a very deep blood-red, with a faint admixture of blue. 2. The rock-ruby, a name very improperly given to the garnet, when it is of a very strong but not deep red, and has a fairer cast of the blue; this is a very beautiful gem. 3. The sorane or serain garnet, that of a yet brighter red, approaching to the colour of a native cinnabar, with a faint blue tinge. 4. The almandine, a garnet only a little paler than that called the rock-ruby.

Garnets are very properly distinguished into the oriental and occidental kinds, as being found in Europe as well as the East Indies. The oriental ones are principally brought from Calicut, Cananor, and Cambay; and the European are common in Italy, Hungary, and Bohemia.

Some authors have supposed the deeper-coloured garnet to be the same with the carbuncle of the ancients, from which it really differs; since, on receiving the sun's beams, it never gives so true a fire-colour as the carbuncle.

This stone is found in great plenty in many mountains; it is usually crystallized. The primitive form of its crystals is dodecahedron, whose sides are rhombs with angles of 78° 31′ and 120° 28′. The inclination of the rhombs to each other is 120°. The dodecahedron may be considered as a four-sided prism, terminated by four-sided pyramids. It is divisible into four parallelopipeds, whose sides are rhombs; and each of these may be divided into four tetrahedrons, whose sides are isosceles triangles, equal and similar to either of the halves into which the rhomboidal faces of the dodecahedron are divided by their shorter diagonal. The integrant molecules of garnet are similar tetrahedrons.

The texture of garnet, as Bergman first showed, is foliated. Its fracture commonly conchoidal: causes single refraction: specific gravity 3.75 to 4.188. Colour usually red, often green: brittle: often attracted by the magnet: fusible per se by the blowpipe into a black glass.

Variety 1. Noble garnet. Specific gravity 4 to 4.188: colour deep red inclining to violet: almost always in crystals.

Variety 2. Common garnet. Found in mass and disseminated, sometimes in crystals: fracture uneven, inclining to the conchoidal: specific gravity 3.75 to 4: colour various; shades of green and brown; sometimes hyacinth red and brown red; rarely orange yellow.

A specimen of oriental garnet, analysed by Klaproth, contained

35.75 silica
27.25 alumina
36.00 oxide of iron
0.25 oxide of manganese.
——
99.25

A specimen of red garnet analysed by Vauquelin contained

52.0 silica
20.0 alumina
17.0 oxide of iron
7.7 lime.
——
96.7

And a specimen of black garnet,

43 silica
16 alumina
20 lime
16 oxide of iron
4 water and volat. matter.
—
99.

Pyrop is another species of the garnet. This mineral, which is found in Bohemia, and was formerly distinguished by the name of Bohemian garnet, has been lately separated from the garnet by Werner, and made a distinct species. It is never found crystallized, but only in round or angular fragments, usually small. Colour deep red, which passes to orange when the mineral is exposed to the sun. Very hard. Specific gravity 3.718 to 3.941. Fracture conchoidal, and very brilliant. According to the analysis of Klaproth, it is composed of

40.00 silica
28.50 alumina
10.00 magnesia
3.50 lime
16.50 oxide of iron
0.25 oxide of manganese.
——
98.75

Garnet, in a ship, is a tackle having a pendant coming down from the mainmast, with a block well seized to the main-stay, just over the hatchway, to which a guy is fixed to keep it steady; and at the other end is a long tackle-block, in which the fall is reeved, that so by it any goods or casks may be hauled and hoisted into or out of the ship. When this garnet is not used, it is fastened along the stay.

GARNISH, in law books, signifies to warn; in which sense, to garnish the heir, is mentioned in stat. 27 Eliz. c. 3.

GARNISHEE, is used for the third person or party in whose hands money is attached within the liberties of the city of London, in the sheriff's court there; and he is so called, because he has had garnishment or warning not to pay the money, but to appear and answer to the plaintiff creditor's suit.

GARNISHMENT, is a warning given to a person for his appearance, for the better furnishing of the cause and court; as where a person is sued for detaining charters or other writings delivered him by the plaintiff, and another person, upon some certain conditions; and therefore he prays that the other person may be warned to plead with the plaintiff, whether the conditions are or are not performed, which is the praying of garnishment; and interpreted to be either a warning of that other, or a furnishing the court with parties sufficient to determine the cause.

GARRISON, in the art of war, a body of forces dis-

posed in a fortress, to defend it against the enemy, or to keep the inhabitants in subjection, or even to be subsisted during the winter season: hence, garrison and winter quarters are sometimes used indifferently, for the same thing, and sometimes they denote different things. In the latter case, a garrison is a place wherein forces are maintained to secure it; and where they keep regular guard, as a frontier town, a citadel, castle, tower, &c. The garrison should always be stronger than the townsmen. Garrison or winter-quarters signify a place where a number of forces are laid up in the winter season, without keeping the regular guard.

Garrison Guns, such as are mounted and used in a garrison, consisting of the following weights, viz. the 42, 32, 24, 18, 12, 9, and 6 pounders; being made either of brass or iron.

TABLE

Of the Weight and Dimensions of Garrison Guns.

Brass Garrison Guns.						Iron Garrison Guns.					
Shot.	Length		Weight.			Shot.	Length.		Weight.		
lb.	ft.	in.	Cw	qr.	lb	lb.	ft.	in.	Cw.	qr.	lb.
42	10	0	64	0	0	32	9	8	56	0	0
2	9	2	49	2	18	24	9	8	48	0	0
24	8	4	37	0	0	18	9	0	36	0	0
18	7	6	27	3	0	12	7	8	24	0	0
12	6	7	18	2	0	9	7	0	18	0	0
9	6	0	13	3	0	6	6	1	12	0	0
6	5	3	9	1	0	4	5	4	8	0	0

GARTER, *order of the*, a military order of knighthood, the most noble and ancient of any lay order in the world, instituted by king Edward III. This order consists of twenty-six knights companions, generally princes and peers, whereof the king of England is the sovereign or chief. They are a college or corporation, having a great and little seal. Their officers are a prelate, chancellor, register, king at arms, and usher of the black rod. They have also a dean with twelve canons and petty canons, vergers, and twenty-six pensioners, or poor knights. The prelate is the head. This office is vested in the bishop of Winchester, and has ever been so. Next to the prelate is the chancellor, which office is vested in the bishop of Salisbury, who keeps the seals, &c. The next is the register, who by his oath is to enter upon the registry, the scrutinies, elections, penalties, and other acts of the order, with all fidelity. The fourth officer is garter, and king at arms, being two distinct offices united in one person. Garter carries the rod and sceptre at the feast of St. George, the protector of this order, when the sovereign is present. He notifies the elections of new knights, attends the solemnity of their installations, carries the garter to the foreign princes, &c. He is the principal officer within the college of arms, and chief of the heralds.

All these officers, except the prelate, have fees and pensions. The college of the order is seated in the castle of Windsor, with the chapel of St. George, and the chapter-house, erected by the founder for that purpose. The habit and ensign of the order are a garter, mantle, cap, george, and collar. The first four were assigned the knights-companions by the founder; and the george and collar by Henry VIII. The garter challenges pre-eminence over all the other parts of the dress, for from it the noble order is denominated; and it is the first part of the habit presented to foreign princes, and absent knights, who, and all other knights elect, are therewith first adorned; and it is of so great honour and grandeur, that by the bare investitute with this noble ensign, the knights are esteemed companions of the greatest military order in the world. It is worn on the left leg between the knee and calf, and is enamelled with this motto, *honi soit qui mal y pense*, *i. e.* "shame to him that evil thinks hereof." The meaning of which is, that king Edward who laid claim to the kingdom of France, retorted shame and defiance upon him that should dare to think amiss of the just enterprize he had undertaken, for recovering his lawful right to that crown, and that the bravery of those knights whom he had elected into this order, was such as would enable him to maintain the quarrel against those that thought ill of it.

The mantle is the chief of those vestments made use of upon all solemn occasions. The colour of the mantle is by the statutes appointed to be blue. The length of the train of the mantle only distinguishes the sovereign from the knights-companions. To the collar of the mantle is fixed a pair of long strings, anciently woven with blue silk only, but now twisted round, and made of Venice gold and silk, of the colour of the robe, with knobs, or buttons, and tassels at the end. The left shoulder of the mantle has from the institution been adorned with a large garter, with the device *honi soit*, &c. within this is the cross of the order, which was ordained to be worn at all times by king Charles I. At length the star was introduced, being a sort of cross irradiated with beams of silver.

The collar is appointed to be composed of pieces of gold in fashion of garters, the ground enamelled blue, and the motto gold. The manner of electing a knight-companion into this most noble order, and the ceremonies of investure, are as follow. When the sovereign desires to elect a companion of the garter, the chancellor belonging to this order draws up the letters, which passing both under the sovereign's sign manual and signet of the order, are sent to the person by garter principal king at arms, and are in this manner, or to the same effect: "We with the companions of our most noble order of the garter, assembled in chapter, holden this present day at our castle at Windsor, considering the virtuous fidelity you have shown, and the honourable exploits you have done in our service, by vindicating and maintaining our right, &c. have elected and chosen you one of the companions of our order. Therefore we require you to make your speedy repair unto us, to receive the ensigns thereof, and be ready for your installation upon upon the — day of this present month, &c."

The garter, which is of blue velvet bordered with fine gold wire, having commonly the letters of the motto of the same, is, at the time of election, buckled upon the left leg, by two of the senior companions, who receive it

from the sovereign, to whom it was presented upon a velvet cushion by garter king at arms, with the usual reverence, whilst the chancellor reads the following admonition, enjoined by the statutes: "To the honour of God omnipotent, and in memorial of the blessed martyr St. George, tie about thy leg, for thy renown, this noble garter; wear it as the symbol of the most illustrious order, never to be forgotten or laid aside; that thereby thou mayest be admonished to be courageous, and having undertaken a just war in which thou shalt be engaged, thou mayest stand firm, valiantly fight, and successively conquer."

The princely garter being thus buckled on, and the words of its signification pronounced, the knight elect is brought before the sovereign, who puts about his neck, kneeling, a sky-coloured ribbon, to which is appendant, wrought in gold within the garter, the image of St. George on horseback, with his sword drawn, encountering with the dragon. In the mean time, the chancellor reads the following admonition: "Wear this ribbon about thy neck, adorned with the image of the blessed martyr and soldier of Christ, St. George, by whose imitation provoked, thou mayest so overpass both prosperous and adverse adventures, that having stoutly vanquished thine enemies both of body and soul, thou mayest not only receive the praise of this transient combat, but be crowned with the palm of eternal victory."

Then the knight elected kisses the sovereign's hand, thanks his majesty for the great honour done him, rises up, and salutes all the companions severally, who return their congratulations.

Since the institution of this order, there have been eight emperors, and twenty-eight kings, besides numerous sovereign princes, enrolled as companions. Its origin is somewhat differently related: the common account is, that it was erected in honour of a garter of the countess of Salisbury, which she dropped dancing with king Edward, and which that prince picked up; but our best antiquarians think it was instituted on account of the victory over the French at Cressy, where the king ordered his garter to be displayed as a signal of the battle.

GAS, among chemists, a term made use of to denote all the aerial and permanently elastic fluids, except the atmospheric air. See Air.

GASTEROSTEUS, Stickleback, in ichthyology, a fish of the order thoracici. The generic character is, body somewhat lengthened: dorsal spines distinct: ventral fins spiny: abdomen carinated or shielded on the side, and bony beneath. There are eleven species: the following are the principal:

1. Gasterosteus aculeatus, common stickleback. This minute fish is an almost universal inhabitant of ponds, rivers, and marshes, occurring sometimes even in salt or brackish waters. When in its full perfection of colour it is highly beautiful; the gills and abdomen being of a bright red, the back a fine olive-green, and the sides silvery. It is chiefly in the early part of summer that it appears thus decorated; the colours in a great degree fading as the season advances. The general length of this species is about two inches, but it sometimes arrives to the length of three: the ventral fins consist merely of a very strong and serrated spine on each side, accompanied by a single short ray.

The stickleback or banstickle is a fish of an extremely active and vigorous nature, swimming rapidly, and preying on the smaller kind of water-insects and worms, as well as on the spawn of other fishes, and is from this circumstance considered as highly prejudicial to fish-ponds. In the Philosophical Transactions we find some observations relative to the natural history of this fish by Mr. Henry Baker, who informs us that it will spring occasionally to the perpendicular height of not less than a foot out of the water, and to a much greater space in an oblique direction, when wishing to get over stones or other obstacles. "It is scarcely to be conceived," says this writer, "what damage these little fish do, and how greatly detrimental they are to the increase of all the fish in general among which they live; for it is with the utmost industry, sagacity, and greediness, that they seek out and destroy all the young fry that come in their way, which are pursued with the utmost eagerness, and swallowed down without distinction, provided they are not too large: and in proof of this I must assert that a banstickle which I kept for some time did on the 4th of May devour in five hours time seventy-four young dace, which were about a quarter of an inch long, and of the thickness of a horsehair: two days after, it swallowed sixty-two, and would, I am persuaded, have eaten as many every day, could I have procured them for it."

The stickleback is sometimes observed to swarm in prodigious multitudes in some particular parts of Europe. We are told by Mr. Pennant that at Spalding in Lincolnshire, there are, once in seven years, amazing shoals, which appear in the Welland, and come up the river in the form of a vast column: they are supposed to be the multitudes that have been washed out of the fens by the floods of several years, and collected in some deep hole, till, overcharged with numbers, they are periodically obliged to attempt change of place; the quantity is so great that a man employed to take them has got for a considerable time four shillings a day by selling them at the rate of a half-penny per bushel.

2. Gasterosteus spinachia, fifteen-spined stickleback, is much larger than the preceding species, and of a much more slender form; general length from five to six or seven inches; head of a produced and somewhat tubular shape; hinder parts very slender towards the tail; lateral line broad, and composed of a series of small dusky laminæ or scuta; dorsal spines concealed at pleasure in a longitudinal channel; ventral fins each composed of two spines; the first long, the next short: native of the European seas, frequenting shallow places, and preying on marine insects, and the spawn of other fishes; sometimes seen in vast numbers about the coasts of Holland, &c. and occasionally used, like the common stickleback, for the purpose of manuring land, as well as for the preparation of oil for lamps, &c.

GASTRIC Juice, among physicians, a thin, pellucid, spumous, and saltish liquor, which continually distils from the glands of the stomach, for the dilution of the food. See Digestion.

GASTROBRANCHUS, in ichthyology, a genus of fishes of the order chondropterigius: the generic character is, body eel-shaped; mouth beneath, with numerous pectinate teeth; spiracles two, beneath the abdomen.

1. Gastrobranchus cæcus, blind gastrobranchus. The

fish which constitutes this genus has long since been described by Linnæus and others under the title of myxine glutinosa, and considered as belonging to the tribe of vermes, in which situation it ranks in the latest editions of the Systema Naturæ. Dr. Bloch, however, from accurate examination both of its external and internal structure, has very justly considered it as a legitimate cartilaginous fish. The usual length of the European specimens is from four to six inches, but in the Indian ocean it appears to arrive at a far superior size, nearly equalling in this respect the common eel. In its general appearance it bears a near resemblance to the lampreys, with which by Kalm, its first describer, it has been associated. It is remarkable for the total want of eyes, not the least vestige of any such organs being discoverable by the most attentive examination: the mouth, which is situated beneath, as in the lampreys, is of an oblong form; on each side are two beards or cirri, and on the upper part four; in front of the top of the head is a small spout-hole, furnished with a valve, by which it can at pleasure be closed; the teeth, which are situated very deep in the mouth, and are of an orange-colour, as in the lamprey, are disposed on each side into a double row, in form of a pectinated bone; each upper row consisting of nine and each lower row of eight teeth; and in the middle of the roof of the mouth is a single, sharp-pointed, and curved tooth; no nostrils are discoverable; the body is destitute of scales, lateral line, and every kind of fin, except that which forms the tail; this fin is shallow, and commencing at the lower part of the back, runs round the extremity of the body, and is continued beneath as far as the vent; the extremity of the body, where it is surrounded by the caudal fin, is taper or pointed; beneath the body, from head to tail, runs a double row of pretty conspicuous, equidistant pores, through which on pressure, exudes a viscid fluid, and at somewhat more than a third of the animal from the head, are situated beneath the body, the two spiracula, which consist of a pair of oval apertures.

The manners of this fish are represented as highly singular; it is said to enter into the bodies of such fishes as it happens to find on the fishermen's hooks, and which consequently have not the power of escaping its attack, and by gnawing its way through the skin to devour all the internal parts, leaving only the bones and the skin remaining. Another particularity in this animal consists in its uncommonly glutinous nature; if put into a large vessel of sea-water, it is said in a very short space to render the whole so glutinous as easily to be drawn out into the form of threads; when taken out of water the gastro-branchus is said to be incapable of living more than three or four hours. It is an inhabitant of the northern seas, and appears also to occur in those of the southern hemisphere, where, as before mentioned, it arrives at a much larger size than in the northern regions.

2. Dombeyan gastrobranchus. Size much larger than the European specimens of the gastrobranchus cæcus: head rounded, and broader than the body; on the upper lip four beards; number of those on the lower uncertain, the specimen being described in a dried state; teeth pointed, compressed, triangular, and disposed in two circular ranges, the exterior of which is composed of twenty-two, and the interior of fourteen teeth; a single tooth longer than the rest, and of a curved form in the roof of the mouth, as in the European species; eyes and nostrils imperceptible; colour uncertain; tail rounded at the extremity, and terminated by a very shallow fin united with the anal. Native of the South American seas; observed by Mons. Dombey, and described by Cepede from the dried skin in the Paris museum.

GASTROGRAPHY, in surgery, the operation of sowing up wounds of the abdomen. See SURGERY.

GATE, in a military sense, is made of strong planks, with iron bars, to oppose an enemy. They are generally made in the middle of the curtin, from whence they are seen, and defended by the two flanks of the bastions. They should be covered with a good ravelin, that they may not be seen or enfiladed by the enemy. These gates, belonging to a fortified place, are passages through the rampart, which may be shut and opened by means of doors and a portcullis. They are either private or public.

Private gates are those passages by which the troops can go out of the town unseen by the enemy, when they pass to and from the relief of the duty in the outworks, or on any other occasion which is to be concealed from the besiegers.

Public gates are those passages through the middle of such curtins, to which the great roads of public ways lead. The dimensions of these are usually about 13 or 14 feet high, and 9 or 10 feet wide, continued through the rampart, with proper recesses for foot-passengers to stand in, out of the way of wheel-carriages.

GAVELKIND, a custom principally to be found among the men of Kent, and supposed to be one of the effects of the gallant struggles they made to preserve their liberty, though it is sometimes found in other parts of the kingdom. This tenure has various consequences: the principal are, 1. The tenant can alien his estate by feoffment at the age of 15. 2. The estate does not escheat in case of an attainder and execution for felony. 3. In most places he had a power of devising his estate by will, before the statute was made to restrain him. 4. The lands descend to all the sons equally together, according to the ancient course of descent in England, and not according to primogeniture.

GAVELET, in law, an ancient and special cessavit used in Kent, where the custom of gavelkind continues, by which the tenant, if he withdraws his rent and services due to the lord, forfeits his lands and tenements.

The process of the gavelet is thus. The lord is first to seek by the steward of his court, from three weeks to three weeks, to find some distress upon the tenement, till the fourth court; and if at that time he find none, at this fourth court it is awarded, that he take the tenement in his hand in name of a distress, and keep it a year and a day without manuring; within which time, if the tenant pays his arrears, and make reasonable amends for the withholding, he shall have and enjoy his tenement as before: if he come not before the year and day be past, the lord is to go to the next county-court with witnesses of what had passed at his own court, and pronounce there his process, to have further witnesses; and then by the award of his own court, he shall enter and manure the tenement as his own; so that if the tenant desired afterwards to have and hold it as before, he must

agree with the lord; according to this old saying, "Has he not since any thing given, or any thing paid, then let him pay five pound for his were, e'er he become healder again." Other copies have the first part with some variation; "Let him nine times pay, and nine times repay."

Gavelet, in London, is a writ used in the hustings, given to lords of rents in the city of London. Here the parties, tenant and demandant, appear by scire facias, to show cause why the one should not have his tenement again on payment of his rent, or the other recover lands on default thereof.

GAUGE-POINT, of a solid measure, the diameter of a circle, whose area is equal to the solid content of the same measure. Thus the solidity of a wine-gallon being 231 cubic inches, if you conceive a circle to contain so many inches, the diameter of it will be 17.15; and that will be the gauge-point of wine-measure. And of an ale-gallon, containing 282 cubic inches, by the same rule, the gauge-point for ale-measure will be found to be 19.15. After the same manner, may the gauge-point of any foreign measure be obtained; and hence may be drawn this consequence, that when the diameter of a cylinder, in inches, is equal to the gauge-point of any measure, given likewise in inches, every inch in length thereof will contain an integer of the same measure, *e. g.* in a cylinder whose diameter is 17.15 inches, every inch in height contains one entire gallon in wine-measure; and in another, whose diameter is 18.95 inches, every inch in length contains one ale-gallon.

GAUGER, a king's officer, who is appointed to examine all tuns, pipes, hogsheads, and barrels of wine, beer, ale, oil, honey, &c. and give them a mark of allowance, before they are sold in any place within the extent of his office.

There are divers statutes that mention this officer and his office; as by 27 Ed. III. c. 8. all wines, &c. imported are to be gauged by the king's gaugers, or their deputies, otherwise they shall be forfeited, or their value; and on default of the gauger, that he be not ready to do his office when required, or that he defrauds in doing his office to the damage of the buyer or seller, he shall pay the party grieved his treble damage, lose his office, be punished by imprisonment, and be ransomed at the king's will: and in case less is found in the tun or pipe than ought to be, the value of as much as shall lack, shall be deducted in the payment.

Every gauger shall truly, within the limits of his office, gauge all tuns, butts, pipes, tierces, puncheons, tertians, hogsheads, barrels, and runlets; and mark on the head of every vessel the contents, upon pain of forfeiting to the party to whose use the wine, &c. shall be sold, four times the value of that which the vessel marked shall lack of its content: the same forfeiture shall be recovered by an original writ, &c. and every person selling the wine, &c. in the vessel marked, shall allow of the price, the value of gauge, or default of filling, upon pain of forfeiture to the buyer, of double the value, to be recovered with costs as before. No brewer shall put to sale any beer or ale in vessels brought from beyond the sea, within the city of London, or suburbs of the same, or within two miles compass without the suburbs, before the same is gauged, and the true content of every such vessel set upon the same, by the gallon appointed for beer and ale, according to the standard, by the master and wardens of the coopers of London.

GAUGING, the art or act of measuring the capacities or contents of all kinds of vessels, and determining the quantities of fluids or other matters contained therein.

To gauge any vessel, or to find the quantity of liquor it can contain,

Find how many solid inches will fill the cavity of the vessel, and divide these by the number of solid inches which make a pint or gallon; the quotient is the content of the vessel in pints or gallons.

TABLE *of Cubic Inches in several Measures.*

282	Cubic inches	= 1 English ale gallon
231	Ditto	= 1 English wine gallon
268.8	Ditto	= 1 English corn gallon
2150.4	Ditto	= 1 English corn or malt bushel.

From these divisors, multipliers may be found thus: Divide 1 by any number in this table, the quotient is a constant multiplier, by which the content of any vessel in cubic inches being multiplied, the product is its content in that measure for which the multiplier was found.

TABLE *of Divisors and Multipliers.*

282	.003546 ale gallons
231	.004329 wine gallons
268.8	.0037202 corn gallons
2150.42	.00046502 malt bushels.

In gauging vessels, the dimensions are always taken in inches and decimals of an inch.

Ex. 1. Suppose a vessel in form of a parallelopiped, the length of its base 27 inches, breadth $16\frac{1}{2}$ inches, and the depth of the vessel $32\frac{1}{4}$ inches; required the content in English ale gallons?

$$27 \times 16.5 \times 32.25 = 14367.375 \text{ cubic inches.}$$

If you divide 14367.375 by 282, or multiply them by 003546, the result will be the content of the vessel in English ale gallons, viz. 50.946.

In the same manner, the content of any vessel may be found; but those who practice gauging proceed thus:

In any vessel equally wide from top to bottom, they compute the area of its base in square inches; and, by dividing or multiplying these by the numbers in the tables, get what they call the area in gallons, (that is, the number of gallons which the vessel contains when the liquid is only one inch deep), which multiplied by the depth of the liquid, gives the quantity contained in the vessel.

Ex. 2. Suppose a trough, or cistern, in form of a right-angled parallelopiped, its base 27 inches long, and $16\frac{1}{2}$ inches wide, and the height of the vessel $32\frac{1}{2}$ inches, but the depth of liquor only 20 inches; required its content in English ale gallons? *Ans.* 31.594.

$27 \times 16.5 \times .003546 = 1.579743$, the area of the base in gallons, which multiplied by 20, produces 31.594 ale gallons.

Ex. 3. Suppose a cylindric vessel hath the diameter of its base 20 inches, and its height 30 inches; required the content in wine gallons? *Ans.* 40.8.

$$20 \times 20 \times .7854 \times 30 \times .004329 = 40.8.$$

Suppose a tub having circular bases, the diameter of the mouth is 60 inches, and the diameter of the bottom is 36 inches, and the perpendicular depth from top to bot-

tom is 30 inches; required its content in English ale gallons?

This vessel is to be considered as the frustum of a cone; and, on this supposition its content will be 55417.8 cubic inches; which, by reduction, is 196.5 English ale gallons.

The calculation is tedious by common arithmetic, but may be easily performed by logarithms; thus, To twice the logarithm of the diameter of one base add the logarithm of .7854, the sum is the logarithm of the area of that base. Do the same for the area of the other base, and find the numbers answering to each. Then add the logarithms of the areas of the two bases, and take half of the sum, and find the number answering thereto. Add the areas of the two bases, and the last-found number, and multiply the sum by one-third part of the depth, the product is the content in cubic inches.

Operation for the last Example.

	Log.		Log.
Diameter 60	1.7781513	Diameter 36	1.5563025
	1.7781513		1.5563025
7854	9.8950909	.7854	9.8950909
2827.44	3.4513935	1017.8784 =	3.0076959
1017.8784		2827.44	3.4513935
1696.464			2)6.4590894
5541.7824			
Mult. by 10		1696.464 =	3.2295447
55417.824 Ans.			

The content of any vessel of this form may be found with less trouble by this rule:

To the product of the diameters of the two bases, add one-third part of the square of their difference; the sum is the square of a mean diameter; which being multiplied by .7854, and the product by the depth of the vessel, gives the content in cubic inches.

Exam. Let the diameter of the greater base be 60, and of the lesser base 57.6, and the perpendicular height of the tub 29.976 inches; required its content? *Ans.* 81410.3 cubic inches.

To Gauge a CASK.—Casks are distinguished into the following four varieties:

1. Such as resemble the middle frustum of a spheroid.
2. Such as resemble the middle frustum of a parabolic spindle.
3. Such as being cut through in the middle, the two parts are parabolic conoids.
4. Such as being cut through in the middle, the parts are the lower frustums of two equal cones.

Measure the head and bung diameters, and the length of the cask in inches; and then,

1. If the staves are very much curved, the cask is supposed to be the middle zone, or frustum of a spheroid: and its content may be found by this rule:

To twice the square of the bung diameter, add the square of the head diameter; multiply the sum by the length of the cask, and divide the product by 3.8197, the the quotient is the content in cubic inches.

Exam. Suppose there is a spheroidal cask, its bung diameter = 31.5 inches, head diameter = 24.5 inches, and the length of cask = 42 inches; required its content in English ale gallons?

Ans. 100.78.

2. If the staves of a cask are less curved than was supposed in the last article, the cask is taken for the middle frustum, or zone, of a parabolic spindle; and its content is computed by this rule:

To twice the square of the bung diameter, add the square of the head diameter, and from the sum subtract four-tenths of the square of the difference of the diameters; divide the remainder by 3.8197, and multiply the quotient by the length of the cask; the product is its content in cubic inches.

Exam. Let the bung diameter = 34 inches, the head diameter = 30, and the length of the cask = 40 inches; what is its content in English ale gallons? *Ans.* 119.039.

3. When the staves of a cask are very little curved, the cask is supposed to consist of the two lower frustums of two equal parabolic conoids, their greatest bases joined together in the middle of the cask; the content of such a vessel may be found by this rule:

To the spuare of the bung diameter, add the square of the head diameter; multiply the sum by .3927, and the product by the length of the cask; the last product is the content in cubic inches.

Exam. Let the bung diameter of such a cask = 32 inches, the head diameter = 29, and the length of the cask = 42 inches; required its content in cubic inches and ale gallons?

Ans. 30760.191 cubic inches, or 109.07 ale gallons.

4. If the staves of a cask are straight between the bung and the ends of the cask, the vessel is supposed to consist of the two lower frustums of equal cones; and its content is found by this rule:

To the sum of the square of the head and bung diameters add their product; multiply the sum by the length of the cask, and divide the product by 3.8197; the quotient is the content in cubic inches.

Exam. Required the content of a cask in ale gallons, its bung diameter being 32 inches, its head diameter 24 inches, and the length 40 inches? *Ans.* 87.93.

By these rules, the content of any cask may be found, it being known to which of the four varieties the cask belongs; but in common practice, a mean diameter, whereby the cask is reduced to a cylinder in either variety, is found thus:

5. Multiply the difference between the bung and head diameters by .7 for the spheroid, by .65 for the spindle, by .6 for the conoids, and by .55 for the cones; add the product to the head diameter; the sum is a mean diameter; or the diameter of the base of a cylinder equal to the cask, their lengths being the same. The mean diameter being squared and multiplied by .7854, and the product by the length of the cask, gives the content in cubic inches, which may be reduced to gallons by the table.

Ex. Suppose the bung diameter is 30 inches, the bead diameter 20 inches, and the length of the cask 40 inches, required its content in ale gallons according to each variety.

DIFFERENCE *of* BUNG *and* HEAD DIAMETERS *is* 10 INCHES. M. D.

$10 \times .7 = 7.$ and $20 + 7. = 27.$ for the spheroid,

$10 \times .65 = 6.5$ and $20 + 6.5 = 26.5$ for the spindle.
$10 \times .6 = 6.$ and $20 + 6. = 26.$ for the conoids.
$10 \times .55 = 5.5$ and $20 + 5.5 = 25.5$ for the cones.

For the CONTENT *in* ALE GALLONS.

$27. \times 27. \times .7854 \times 40 \times .003546 = 81.21$ spheroid
$26.5 \times 26.5 \times .7854 \times 40 \times .003546 = 78.23$ spindle
$26. \times 26. \times .7854 \times 40 \times .003546 = 75.3$ conoids
$25.5 \times 25.5 \times .7854 \times 40 \times .003546 = 72.43$ cones.

Mr. Ward, who had much practice in gauging, says, he never gauged a cask that contained so much as the first variety makes it; and therefore, recommends the 2d and 3d varieties as the best general rules for gauging casks.

The following rule is given by Dr. Hutton, which is not only general for all casks that are commonly met with, but easily to be worked, and accurate in its application.

General Rule. Add into one sum,
39 times the square of the bung diameter,
25 times the square of the head diameter, and
26 times the product of those diameters;
multiply the sum by the length of the cask, and the product by the number .00034; then this last product divided by 9 will give the wine gallons, and divided by 11 will give the ale gallons.

Or, $\overline{39B^2 + 25H^2 + 26BH} \times \frac{L}{114}$ is the content in inches; which being divided by 231 for wine gallons, or by 282 for ale gallons, will be the content.

For Ex. If the length of a cask be 40 inches, the bung diameter 32, and the head diameter 24,

Here	$32^2 \times 39 =$	39936
and	$24^2 \times 25 =$	14400
and	$32 \times 24 \times 26 =$	19968
	the sum	74304
	multiplied by	40
	and divid. by 114)	2972160
	gives	26071 cubic inches;

this divided by 231 gives 112 wine gallons,
or divided by 282 gives 92 ale gallons.

But gauging, as now practised, is chiefly done by means of instruments called gauging rods or rulers, which do the business at once, and answer the question without so much calculation, which is no inconsiderable addition both to the ease and despatch of the work, though it is not so much to be depended on.

The method of gauging which is mostly used, is by the four feet guaging-rod and Everard's sliding-rule; the description and uses of both are as follows:

The four-feet gauging-rod (Plate LXIV. Miscel. fig. 101) is usually made of box, and consists of four rules, each a foot long, and about three-eighths of an inch square, joined together by three brass joints; by which means the rod is rendered four feet long when the four rules are opened, and but one foot when all are folded together. On the first face of this rod, marked 4, are placed two diagonal lines, one for beer and the other for wine; by means of which the content of any common vessel in beer or wine gallons, may be readily found, by putting the brased end of the guaging-rod into the bung-hole of the cask, with the diagonal lines upwards, and thrusting this brased end to the meeting of the head and staves; then with chalk make a mark at the middle of the bung-hole of the vessel, and also on the diagonal lines of the rod, right against or over one another, when the brased end is thrust home to the head and staves; then turn the guaging-rod to the other end of the vessel, and thrust the brased end home to the end as before. Lastly, see if the mark made on the gauging-rod, come even with the mark made on the bung-hole, when the rod was thrust to the other end, which if it be, the mark made on the diagonal lines will, on the same lines, show the whole content of the cask in beer or wine gallons. If the mark made on the bung-hole be not right against that made on the rod, when you put it the other way, then right against the mark made on the bung-hole, make another on the diognal lines; and the divisior on the diagonal line, between the two chalks, will show the whole content of the vessel in beer or wine gallons.

Thus, if the diagonal line of a vessel be 284-10 inches, its content in beer-gallons will be nearly 51, and in wine, gallons 62.

If a vessel be open as a half-barrel, tun, or copper, and the measure from the middle on one side to the head and staves be 38 inches, the diagonal line gives 122 beer-gallons; half of which, viz. 61, is the content of the half-tub.

If you have a large vessel, as a tun or copper, and the diagonal line taken by a long rule be 70 inches, then every inch at the beginning-end of the diagonal line call 10 inches; thus 10 inches become 100 inches, and every tenth of a gallon call 100 gallons, and every whole gallon call 1000 gallons.

Example. At 44.8 inches on the diagonal beer line is 200 gallons; so that 4 inches 48 parts, now called 44 inches eight-tenths, is just two-tenths of a gallon, now called 200 gallons; so also, if the diagonal line be 76 inches and seven-tenths, a close cask of such diagonal will hold 1000 beer-gallons; but an open cask but half so much, viz. 500 beer-gallons.

On the second face, 5, are a line of inches and the gauge-line, which is a line expressing the areas of circles (whose diameters are the correspondent inches) in ale gallons; at the beginning is written ale-area. Thus, to find the content of any cylindrical vessel in ale-gallons, seek the diameter of the vessel in inches, and just against it, on the gauge-line, is the quantity of ale-gallons contained at one inch deep; this multiplied by the length of the cylinder, will give its contents in ale-gallons.

On the third face, 6, are three scales of lines; the first, at the end of which is written hogshead, is for finding how many gallons there are in a hogshead, when it is not full, lying with its axis parallel to the horison. The second line, at the end of which is written B. L. is for the same purpose. The third is to find how much liquor is wanting to fill up a butt, when it is standing; at the end of it is wrote B. S. signifying, butt standing.

Half-way the fourth face of the gauging-rod, 7, there are three scales of lines, to find the wants in a firkin, kilderkin, and barrel, lying with their areas parallel to the horizon. They are distinguished by the letters F. K. B. signifying a firkin, kilderkin, and barrel.

Use of the gauge-line.—To find the content of any cylindrical vessel in ale-gallons, seek the diameter of the vessel in inches, and just against it on the gauge-line is the quantity of ale-gallons contained in one inch deep; this

multiplied by the length of the cylinder will give its content in ale-gallons. For example, suppose the length of the vessel 32.06, and the diameter of its base 25 inches, to find what is the content in ale-gallons? Right against 25 inches on the gauge-line is one gallon and .745 of a gallon; which multiplied by 32.06, the length, gives 55.9447 gallons for the content of the vessel. The bung diameter of a hogshead being 25 inches, the head diameter 22 inches, and the length 32.06 inches, to find the quantity of ale-gallons contained in it? Seek 25, the bung diameter, on the line of inches, and right against it on the gauge-line you will find 1.745: take one-third of it, which is .580, and set it down twice; seek 22 inches in the head diameter, and against it you will find on the gauge-line 1.356; one-third of which added to twice .580 gives 1.6096; which multiplied by the length 32.06, the product will be 51.6, the content in ale-gallons.

Everard's sliding-rule is principally used in gauging, being ordinarily made of box, a foot long, an inch broad, and 1 6-10th inch thick, with two small scales to slide in it, which may be drawn out, one towards the right hand, and the other towards the left, till the whole be 3 feet long.

To gauge malt.—1. If the malt lies on the floor in a rectangular form, multiply the length by the breadth, and the product by the depth, all taken in inches; the product is the number of cubic inches in the quantity; which being divided by 2150.42, the quotient is the number of bushels.

The same rule serves for finding the quantity of malt contained in any vessel in form of a parallelopipedon.

Exam. Suppose a quantity of malt on the floor, 288 inches long, 144 inches broad, and $9\frac{1}{2}$ inches deep; required the number of bushels?

Ans. 183.21.

2. When malt is in a cistern, or any vessel, the content of the vessel is to be found in cubic inches, by some of the former rules, and then divided by 2150.42, the quotient is the number of bushels.

3. To find the solidity of any irregular solid.

Put the irregular body into any vessel, and fill it with water; take out the body, and the water will fall lower, and leave a part of the vessel empty, equal to the solidity of the body to be measured; then measure so much water by a vessel of a known capacity as shall fill up the empty space; and the number of cubic inches in that space, and consequently in the irregular body, will be known.

GAULTHERIA, a genus of the class and order decandria monogynia. The cal. outer, 2-leaved, inner 5-cleft; cor. ovate; nect. with 10 dagger-points; caps. 5-celled, covered with the inner calyx, now become a berry. There is one species, a small but beautiful shrub of Canada.

GAURA, a genus of the class and order octandria monogynia. The calyx is four-cleft, tubulous; corolla four-petalled, rising towards the upper side; nect. inferior, one-seeded, four-cornered. There is one species, a biennial plant of North America.

GAURS, an ancient sect of the magicians in Persia. They have a suburb at Ispahan, which is called Gaurabad, or the town of the gaurs, where they are employed only in the meanest and vilest drudgery; but they chiefly abound in Kerman, the barrenest province in all Persia, where the Mahometans suffer them to live with some freedom, and in the full exercise of their religion. Some years ago many of them fled into India, where their posterity remain. They are a poor harmless sort of people, zealous in their superstition, rigorous in their morals, and exact in their dealings; they profess the worship of one God alone, the belief of a resurrection and a future judgment, and utterly detest all idolatry, though the Mahometans believe them to be the most guilty of it. It is true, they perform their worship before fire, for which they have an extraordinary veneration, as believing it to be the most perfect emblem of the Deity. They have the same veneration for Zoroaster that the Jews have for Moses, esteeming him a prophet sent from God.

GAWSE, or GAWZE, in commerce, a very slight, thin, open kind of stuff, made of silk, and sometimes of thread; there are also figured gawzes, and some with gold or silver flowers on a silk ground.

GAZELLE, in zoology. See ANTELOPE, and CAPRA.

GAZONS, in fortification, pieces of fresh earth, covered with grass, and cut in form of a wedge, about a foot long and half a foot thick, to line the outsides of works made of earth, as ramparts, parapets, &c. See FORTIFICATION.

GEARS, or CHAINS, in country-affairs, the trappings and other harness belonging to draught horses or oxen.

GELATINE, in chemistry. If a piece of the fresh skin of an animal, after the hair and every impurity are carefully separated, is washed repeatedly in cold water till the liquid ceases to be coloured, or to subtract any thing; if the skin, thus purified, is put into a quantity of pure water, and boiled for some time, part of it will be dissolved. Let the decoction be slowly evaporated till it is reduced to a small quantity, and then put aside to cool. When cold, it will be found to have assumed a solid form, and to resemble precisely that tremulous substance well known to every body under the name of jelly. This is the substance called in chemistry gelatine. If the evaporation is still farther continued, by exposing the jelly to dry air, it becomes hard, semitransparent, breaks with a glassy fracture, and is, in short, the substance so much employed in different arts under the name of glue. Gelatine then is precisely the same with glue, only that it must be supposed always free from those impurities with which glue is so often contaminated.

Gelatine is semitransparent and colourless when pure. Its consistency and hardness vary considerably. The best kinds are very hard, brittle, and break with a glassy fracture. Its taste is insipid, and it has no smell. When thrown into water it swells very much, but does not readily dissolve; and when taken out, it is soft and gelatinous, but when allowed to dry, it recovers its former appearance. If it is put in this gelatinous state into warm water, it very soon dissolves, and forms a solution of an opal colour, and the more opaque according to the quantity of gelatine which it contains. Tremulous gelatine dissolves in a very small portion of hot water; but as the solution cools, it gelatinizes afresh. If this solution, as soon as it assumes the tremulous form, is mixed with cold water, and shaken, a complete solution takes place. Dry gelatine undergoes no change when kept, but in a gelatinous state, or when dissolved in water,

it very soon putrefies; an acid makes its appearance in the first place (probably the acetic), a fetid odour is exhaled, and afterwards ammonia is formed. When dry gelatine is exposed to heat, it whitens, curls up like horn, then blackens and gradually consumes to a coal; but tremulous gelatine first melts, assuming a black colour. When distilled, it yields, like most animal substances, a watery liquid impregnated with ammonia, and a fetid empyreumatic oil, leaving a bulky charcoal of difficult incineration. It is by no means a very combustible substance.

Acids dissolve gelatine with facility, even when diluted, especially when assisted by heat; but we are still ignorant of the changes produced upon it by these agents, except by nitric acid. When this acid is digested on it, a small quantity of azotic gas is disengaged, then abundance of nitrous gas; the gelatine is dissolved, except an oily matter which appears on the surface, and converted partly into oxalic and malic acids.

Muriatic acid dissolves glue with great ease. The solution is of a brown colour, and still continues strongly acid. It gradually lets fall a white powder. This solution precipitates tan in great abundance from water, and may be employed with advantage to detect tan when an alkali conceals it. Sulphuric acid acts much more slowly. The solution is brown and gradually deepens; sulphurous acid is exhaled during the action of sulphuric acid on glue. Neither sulphuric nor muriatic acid occasion any change in the solution of glue in water. Alkalies also dissolve gelatine with facility, especially when assisted by heat; but the solution does not possess the properties of soap.

None of the earths seem to combine with gelatine; at least they do not pricipitate it from its solution in water. The following table exhibits the effect of different earthly solutions when mixed with a pretty concentrated solution of common glue.

Substances.	Effects.
Lime water	No change.
Strontian water	No change.
Barytes water	Became milky. Precipit not dissolved by acetic acid.
Muriat of barytes	The same as the last.
Silicated potass	No change.
Aluminated potass	No change.
Oxalat of ammonia	Became milky.
Phosphat of soda	Became slightly milky.

The milkiness produced by some of these re-agents was not owing to their effect upon the gelatine, but upon the lime and the sulphuric acid which it contained.

The metals in their pure state have no effect upon gelatine; but several of the metallic oxides, when agitated in a solution of gelatine, have the property of depriving the water of the greatest part of that body, with which they form an insoluble compound. Several of the metallic salts likewise precipitate gelatine from water. The following table exhibits the result of mixing various metallic salts with a concentrated solution of gelatine, as far as experiments have gone.

Metallic Solutions.	Effects.
Nitromuriat of gold	A copious yellowish-white precipitate. Soluble by adding water.
Nitrat of silver	Becomes slightly milky.
Nitrat of mercury	A very copious curdy precipitate.
Oxymuriat of mercury	A copious white precip.
Sup. oxysulphat of mer.	No change.
Dry oxysulphat of mer.	Crystals become yellow, white flakes appear, and the liquid becomes transparent.
Prussiat of mercury	No change.
Oxynitrat of copper	No change.
Muriat of copper	Becomes milky.
Oxysulphat of copper	No change.
Cuprat of ammonia	No change.
Sulphat of iron	A few yellow flakes appear.
Oxysulphat of iron	Becomes slightly milky, as when alcohol is added.
Oxynitrat of iron	Assumes a pink colour.
Oxymuriat of iron	Becomes green.
Nitromuriat of tin	No change.
Oxymuriat of tin	Becomes slowly milky.
Nitrat of lead Acetat of lead Plumbat of potass Plumbat of lime	No change.
Muriat of zinc	No change.
Muriat of antimony	A copious flaky precip.
Tartar emetic	No change.
Nitrat of bismuth precipitable by water	Becomes milky.
Ditto, not precipitable by water	No change.
Muriat of arsenic	No change.

Gelatine is insoluble in alcohol. When alcohol is mixed with a solution of gelatine, the mixture becomes again transparent when agitated, unless the solution is concentrated, and the quantity of alcohol considerable. Gelatine is most probably equally insoluble in ether.

When the solution of tan is dropped into gelatine, a copious white precipitate appears, which soon forms an elastic adhesive mass, not unlike vegetable gluten. This precipitate is composed of gelatine and tan; it soon dries

in the open air, and forms a brittle resinous-like substance, insoluble in water, capable of resisting the greater number of chemical agents, and not susceptible of putrefaction. It resembles exactly overtanned leather. The precipitate is soluble in the solution of gelatine, as Mr. Davy first observed. Neither is the whole tan thrown down, unless the solutions both of tan and gelatine are somewhat concentrated. Tremulous gelatine, as was first observed by the same chemist, does not precipitate tan; but if we employ a solution of gelatine so strong that it galatinizes when cold, and heated till it becomes quite liquid, it answers best of all for throwing down tan. It is by this property of forming a white precipitate with tan that gelatine is usually detected in animal fluids. It is not, however, a perfectly decisive test, as there are two other animal substances, namely, albumen and mucilage, which are thrown down likewise by tan. Gelatine does not, properly speaking, combine with oils, but it renders them miscible with water, and forms a kind of emulsion

From the effects of different reagents on gelatine, and from the decomposition which it undergoes when heated, we see that it contains carbon, hydrogen, azote, and oxygen. But what the proportion of these constituents is, cannot be ascertained. The phosphat of lime, and the traces of soda, which it always yields, are most likely only held in solution by it.

Gelatine, like all other constituents of animal bodies, is susceptible of numerous shades of variations in its properties, and of course is divisible into an indefinite number of species. Several of these have been long known and manufactured for different purposes; and many curious varieties have been pointed out by Mr. Hatchett, in his admirable dissertations on shell, bone, and zoophytes, published in the Philosophical Transactions for 1797 and 1800. The most important species are the following:

1. *Glue.*—This well-known substance has been long manufactured in most countries, and employed to cement pieces of wood together. It is extracted by water from animal substances, and differs in its qualities according to the substances employed. Bones, muscles, tendons, ligaments, membranes, and skins, all yield it; but the quality is best when skins are employed; and those of old animals yield a much stronger glue than those of young animals. English glue is considered as the best, owing to the care with which it is made. The parings of hides, pelts from furriers, the hoofs and ears of horses, oxen, calves, sheep, &c. are the substances from which it is extracted in Britain; and quantities of these substances are imported for the purpose. They are first digested in lime-water to clean them, then steeped in clean water, laid in a heap till the water runs off, and then boiled in brass caldrons with pure water. The impurities are skimmed off as they rise; and when the whole is dissolved, a little alum or finely-powdered lime is thrown in. The skimming having been continued for some time, the whole is strained through baskets, and allowed to settle. The clear liquid is gently poured back into the kettle, boiled a second time, and skimmed till it is reduced to the proper consistency. It is then poured into large frames, where it concretes on cooling, into a jelly. It is cut by a spade into square cakes, which are again cut by means of a wire into thin slices; these slices are put into a kind of coarse net-work, and dried in the open air. The best glue is extremely hard and brittle; it has a dark-brown colour, and an equal degree of transparency without black spots. When put into cold water, it swells very much, and becomes gelatinous, but does not dissolve. When glue is soluble in cold water, it is a proof that it wants strength.

2. *Size.*—This substance differs from glue in being colourless, and more transparent. It is manufactured in the same way, but with more care; eel-skins, vellum, parchment, some kinds of white leather, and the skins of horses, cats, and rabbits, are the substances from which it is procured. It is commonly inferior to glue in strength. It is employed by paper-makers to give strength to that article, and likewise by linen-manufacturers, gilders, polishers, painters in fresco, &c.

3. *Isinglass.*—This substance agrees with size in being transparent, but it is much finer, and is therefore sometimes employed as an article of food. It is prepared in Russia from the air-bladders and sounds of different kinds of fish which occur in the mouths of large rivers; chiefly different species of accipenser, as the sturio, stellatus, huso, ruthenus, and likewise the siluris glaris. The bladder is taken from the fish, clean washed, the exterior membrane separated, cut lengthwise and formed into rolls, and then dried in the open air. When good, isinglass is of a white colour, semitransparent, and dry. It dissolves in water with more difficulty than glue, probably because it is not formed originally by solution. It differs from common glue in being soluble in alcohol. From the analysis of isinglass, by Mr. Hatchett, we learn that it is almost completely convertible into gelatine by solution and boiling. 500 grains of it left by incineration 1.5 grains of phosphat of soda mixed with a little phosphat of lime.

A coarse kind of isinglass is prepared from sea-wolves, porpoises, sharks, cuttle-fish, whales, and all fish without scales. The head, tail, and fins of these, are boiled in water and concentrated by evaporation, till it gelatinizes on cooling: it is then cast into flat slabs, and cut into tablets. This species is used for clarifying, stiffening silk, making sticking-plaster, and other purposes.

Gelatine exists in great abundance in animals, forming the constituent part of their solid and fluid parts. Its uses are numerous. In a state of jelly it constitutes one of the most nourishing and palatable species of food.

GELATINOUS, in pharmacy and medicine, any thing approaching to the glutinous consistence of a gelatine, or jelly.

GELD, or GILD, in law, a fine or compensation for an offence. Hence wergeld, in our ancient laws, was used for the value of a man slain; and orsgeld, of a beast.

GEM, in natural history, a common name for all precious stones, of which there are two classes, the pellucid and semipellucid. See GEMMA.

GEMINI, the Twins, in astronomy, one of the twelve signs of the zodiac, the third in order, beginning with Aries. This constellation, according to different authors, contains from 24 to 89 stars. It is represented by the figure of two twin-children, looking each other affectionately in the face, and supposed to be Castor and Pollux.

GEMMA, in natural history, a common name for all precious stones; of which there are two classes, the pellucid and semipellucid.

The bodies composing the class of pellucid gems are

bright, elegant, and beautiful fossils, naturally and essentially compound, ever found in small detached masses extremely hard, and of great lustre.

The bodies composing the class of semipellucid gems are stones naturally and essentially compound, not inflammable nor soluble in water, found in detached masses, and composed of crystalline matter debased by earth: however, they are but slightly debased, and are of great beauty and brightness, of a moderate degree of transparency, and are usually found in small masses.

The knowledge of gems depends principally on observing their hardness and colour. For hardness, they are commonly allowed to stand in the following order: the diamond the hardest of all; then the ruby, sapphire, hyacinth, emerald, amethyst, garnet, carneol, chalcedony, onyx, jasper, agate, porphyry, and marble. This difference, however, is not regular and constant, but frequently varies. Good crystals may be allowed to succeed the onyx; but the whole family of metallic glassy fluors seem to be still softer. In point of colour, the diamond is valued for its transparency, the ruby for its purple, the sapphire for its blue, the emerald for its green, the hyacinth for its orange, the amethyst carneol for its carnation, the onyx for its tawny, the jasper, agate, and porphyry, for their vermilion, green, and variegated colours, and the garnet for its transparent blood-red.

All these gems are sometimes found coloured and spotted, and sometimes quite limpid and colourless. In this case the diamond-cutter or polisher knows how to distinguish their different species by their different degree of hardness upon the mill. For the cutting or polishing of gems, the fine powder of the fragments of those that are next in degree of hardness is always required to grind away the softer; but as none of them are harder than the diamond, this can only be polished by its own powder.

Cronstedt observes of gems in general, that the colour of the ruby and emerald is said to remain in the fire, while that of the topaz flies off. Hence it is usual to burn the topaz, and then substitute it for the diamond.

With regard to the texture of gems, M. Magellan observes, that all of them are foliated or laminated, and of various degrees of hardness. Whenever the edges of these laminæ are sensible to the eye, they have a fibrous appearence, and reflect various shades of colour, which change successively according to their angular position to the eye. These are called by the French chatorantes; and what is a blemish in their transparency often enhances their value on acount of their scarcity. But when the substance of a gem is composed of a broken texture, consisting of various sets of laminæ differently inclined to each other, it emits at the same time various irradiations of different colours, which succeed one another according to their angle of position. This kind of gems has obtained the name of opals, and are valued in proportion to the brilliancy, beauty, and variety of their colours. Their crystallization, no doubt, depends on the same cause which produces that of salt, earths, and metals. The following table shows in general the component parts of gems according to the analysis of Bergman and M. Achard; the letter B prefixed to each denoting Bergman's analysis, and A that of Achard. We must observe, however, that under the description of the different gems our readers will find much more accurate statements.

		alum.	silex.	lime.	iron.
Red oriental ruby, -	B	40	39	9	10
Ditto, - - -	A	37.5	42.5	9	11
Blue oriental sapphire, -	B	58	35	5	2
Ditto, - - -	A	58	33	6	3
Yellow topaz from Saxony,	B	46	39	8	6
Green oriental emerald, -	B	60	24	8	6
Ditto, - - -	A	60	23	10	7
Yellow-brown oriental hyacinth - - -	B	40	25	20	13
Ditto, - - -	A	42	22	20	16
Tourmalin from Ceylon, -	B	39	37	15	9
Ditto from Brasil, -	B	50	34	11	5
Ditto from Tyrol, -	B	42	40	12	6
Garnet from Bohemia, -	A	30	48	11	10

GEMMA, a bud. See Botany; and Plants, *physiology of.*

GEMONIÆ scalæ, in Roman antiquity, a place for executing criminals. It was situated on the Aventine mount, or tenth region of the city, and was, according to some, a place raised on several steps, whence they precipitated the criminals. But others will have it to have been a kind of dungeon, to which they descended by steps.

GEMS, *factitious*, or *counterfeit*. See Glass.

Gems, *imitation of antique.* There has been at different times a method practised by particular persons, of taking the impressions and figures of antique gems, with their engravings, in glass of the colour of the original gem. This has always been esteemed a very valuable method, and greatly preferable to the more ordinary ones of doing it on sealing-wax or brimstone: but, to the misfortune of the world, this art, being a secret only in the hands of some particular persons who got their bread by it, died with them, and every new artist was obliged to re-invent the method; till at length Mr. Homberg, having found it in great perfection, gave the whole process to the world to be no more forgotten or lost; and since that time it has been very commonly practised in France, and sometimes in other places.

Mr. Homberg was favoured in his attempts with all the engraved gems of the king's cabinet, and took such elegant impressions, and made such exact resemblances of the originals, and that in glasses so artfully tinged to the colour of the gems themselves, that the nicest judges were deceived in them, and often mistook them for the true antique stones. These counterfeit gems also serve, as well as the original ones, to make more copies from afterwards; so that there is no end of the numbers that may be made from one; and there is this farther advantage, that the copy may be easily made perfect, though the original should not be so, but should have sustained some damage from a blow or otherwise.

The great care in the operation is, to take the impression of the gem in a very fine earth, and to press down upon this a piece of proper glass, softened or half-melted at the fire, so that the figures of the impression made in the earth may be nicely and perfectly expressed upon the glass. In general the whole process much resembles that of the common founders. But when it is brought to the trial, there are found a number of difficulties which were

not to be foreseen, and which would not at all affect the common works of the founder. For his purpose every earth will serve that is fine enough to receive the impressions, and tough enough not to crack in the drying; these all serve for their use, because the metals which they cast are of a nature incapable of mixing with earth, or receiving it into them, even if both are melted together, so that the metal always easily and perfectly separates itself from the mould; but it is very difficult in these casts of glass. They are composed of a matter which differs in nothing from that of the mould, but that it has been run into this form by the force of fire, and the other has not yet been so run, and will mix itself inseparably with the glass in a large fire: consequently, if there is not great care used, as well in the choice of the glass as the manner of using it, when the whole is finished, there will be found great difficulty in separating the glass from the mould; and often this cannot be done without wholly destroying the impression.

All earths run more or less easily in the fire as they are more or less mixed with saline particles in their natural formation. As all salts make earths run into glass, and as it is necessary to use an earth on this occasion for the making a mould, it being also necessary, to the perfection of the experiment, that this earth should not melt or run, it is our business to search out for this purpose some earth which naturally contains very little salt. Of all the species of earth which Mr. Homberg examined on this occasion, none proved so much divested of salts, or so fit for the purpose, as the common tripela, or tripoli, used to polish glass and stones. Of this earth there are two common kinds; the one reddish, and composed of several flakes or strata; the other yellowish, and of a simple structure. These are both to be had in the shops. The latter kind is from the Levant; the former is found in England, France, and many other places. This tripela must be chosen soft and smooth to the touch, and not mixed with sandy or other extraneous matter. The yellowish kind is the best of the two, and is commonly called Venetian tripoli. This receives the impression very beautifully, and never mixes with the glass in the operation which the red kind sometimes does. Mr. Homberg usually employed both kinds at once in the following manner: 1st, powder a quantity of the red tripela in an iron mortar, and sifting it through a fine sieve, set it by for use; then scrape with a knife a quantity of the yellow tripela into a sort of powder, and afterwards rub it till very fine in a glass mortar with a glass pestle. The finer this powder is, the finer will be the impression, and the more accurately perfect the cast. The artificer might naturally suppose, that the best method to obtain a perfectly fine powder of this earth, would be by washing it in water; but he must be cautioned against this. There is naturally in this yellowish tripela a sort of unctuosity, which, when it is formed into a mould, keeps its granules together, and gives the whole an uniform glossy surface; now washing the powder takes away this unctuosity; and though it renders it much finer, it makes it leave a granulated surface, not this smooth one, in the mould; and this must render the surface of the cast less smooth.

When the two tripelas are thus separately powdered, the red kind must be mixed with so much water as will bring it to the consistence of paste, so that it may be moulded like a lump of dough between the fingers: this paste must be put into a small crucible of a flat shape, and about half an inch or little more in depth, and of such a breath at the surface as is a little more than that of the stone whose impression is to be taken. The crucible is to be nicely filled with this paste lightly pressed down into it, and the surface of the paste must be strewed over with the fine powder of the yellow tripela not wetted. When this is done, the stone of which the impression is to be taken must be laid upon the surface, and pressed evenly down into the paste with a finger and thumb, so as to make it give a strong and perfect impression; the tripela is then to be pressed nicely even to its sides with the fingers, or with an ivory knife. The stone must be thus left a few moments, for the humidity of the paste to moisten the dry powder of the yellow tripela which is strewed over it; then the stone is to be carefully raised by the point by a needle fixed in a handle of wood, and the crucible being then turned bottom upwards, the stone will fall out, and the impression will remain very beautifully on the tripela. If the sides of the cavity have been injured in the falling out of the stone, they may be repaired, and the crucible must then be set, for the paste to dry, in a place where it will not be incommended by the dust.

The red tripela, being the more common and the cheaper kind, is here made to fill the crucible only to save the other, which alone is the substance fit for taking the impression. When the stone is taken out, it must be examined, to see whether any thing is lodged in any part of the engraving, because, if there is any of the tripela remaining, there will of course be so much wanting in the impression. When the crucible and paste are dry, a piece of glass must be chosen of a proper colour, and cut to a size proper for the figure; this must be laid over the mould, but in such a manner that it shall not touch the figures, otherwise it would spoil them. The crucible is then to be brought near the furnace by degrees, and gradually heated till it cannot be touched without burning the fingers; then it is to be placed in the furnace under a muffle surrounded with charcoal. Several of these small crucibles may be placed under one muffle; and when they are properly disposed, the aperture of the muffle should have a large piece of burning charcoal put to it, and then the operator is to watch the process, and see when the glass begins to look bright: this is the signal of its being fit to receive the impression. The crucible is then to be taken out of the fire, and the hot glass must be pressed down upon the mould with an iron instrument, to make it receive the regular impression; as soon as this is done, the crucible is to be set by the side of the furnace out of the way of the wind, that it may cool gradually without breaking. When it is cold, the glass is to be taken out, and its edges should be grated round with pincers, in order to prevent its flying afterwards, which is an accident that sometimes happens when this caution has been omitted, especially when the glass is naturally tender. The different coloured glasses are of different degrees of hardness, according to their composition; but the hardest to melt are always the best for this purpose, and this is known by a few trials.

If it is desired to copy a stone in relief which is natu-

rally in creux, or to take one in creux which is naturally in relief, there needs no more than to take an impression, first in wax or sulphur, and to mould that upon the paste of tripela instead of the stone itself; then proceeding in the manner before directed, the process will have the desired effect.

A still more simple and easy method is by taking the casts in gypsum, or plaister of Paris, as it is commonly called. For this purpose the gypsum must be finely pulverized, and then mixed with clear water to the consistence of thick cream. This is poured upon the face of the gem or seal of which the impression is wanted, and which must be previously moistened with oil to facilitate the separation of the cast; and in order to confine the liquid plaister it is only necessary to pin a slip of oiled paper round the sides of the seal by way of a cap or rim. When the plaister is dry, it is to be taken off, and set before the mouth of the furnace, in order to free it entirely from moisture, when it is fit to be used as a matrix in the same way as that formed with the tripoli earths. Only no crucible or other receptacle is at all necessary, the casts being formed like so many small cakes half an inch thick, and then put into the furnace with the bits of glass upon them. The glass, after coming to a proper heat, is pressed down upon the mould with an iron spatula to receive the desired impression, the pressure required being more or less, according to the size of the stone. This method has been long practised very successfully, and with no small emolument, by that ingenious seal-engraver, Mr. Denchar of Edinburgh. The only respect in which it is inferior to the other more operose and expensive methods, consists in the chance of air-bubbles arising in pouring on the plaister; which chance, however, is less in proportion to the fineness of the gypsum employed. When air-bubbles do occur, the casts may be laid aside, as it is so easy to replace them.

Of all the artists and ingenious men who have taken impressions of engraved gems in sulphur and in paste, no one seems to have carried that art to such perfection as Mr. James Tassie, a native of Glasgow, but who latterly resided in London.

Mr. Tassie, profiting by the former publications of this sort, and by expense, industry, and access to many cabinets in England and other kingdoms to which former artists had not obtained admission, increased his collection of impressions of ancient and modern gems to the number of above 15,000 articles. It is the greatest collection of this kind that ever existed, and serves for all the purposes of artists, antiquaries, scholars, men of taste, and even philosophers. The great demand for his pastes was perhaps owing in the beginning to the London jewellers, who introduced them into fashion by setting them in rings, seals, bracelets, necklaces, and other trinkets.

The reputation of this collection having reached the empress of Russia, she was pleased to order a complete set; which, being accordingly executed in the best and most durable manner, were arranged in elegant cabinets, and are now placed in the noble apartments of her imperial majesty's superb palace at Czarsko Zelo.

Mr. Tassie, in executing this commission, availed himself of all the advantages which the improved state of chemistry, the various ornamental arts, and the knowledge of the age, seemed to afford. The impressions were taken in a beautiful white enamel composition, which is not subject to shrink or form air-bladders, which emits fire when struck with steel, and takes a fine polish, and which shows every stroke and touch of the artist in higher perfection than any other substance. When the colours, mixed colours, and nature of the respective originals, could be ascertained, they were imitated as completely as art can imitate them; insomuch that many of the paste intaglios and cameoes in this collection are such faithful imitations, that artists themselves have owned they could hardly be distinguished from the originals. And when the colour and nature of the gems could not be authenticated, the pastes were executed in agreeable, and chiefly transparent, colours; constant attention being bestowed to preserve the outlines, extremities, attributes, and inscriptions.

GENDARMERIE, *Fr.* The gendarmerie was a select body of cavalry that took precedence of every regiment of horse in the French service, and ranked immediately after the king's household. The reputation of the gendarmerie was so great, and its services so well estimated by the king of France, that when the emperor Charles V. in 1552, sent a formal embassy to the court of Versailles to request a loan of money, and the assistance of the gendarmerie to enable him to repulse the Turks; Francis I. returned the following answer: "With respect to the first object of your mission, (addressing himself to the ambassador) I am not a banker; and with regard to the other, as my gendarmerie is the arm which supports my sceptre, I never expose it to danger, without myself sharing its fatigue and glory."

The uniform of the gendarmerie, as well as of the light cavalry, under the old French government, was scarlet, with facings of the same colour. The coat was formerly more or less laced with silver, according to the king's pleasure. A short period before the revolution, it was only laced on the cuff. The waistcoat was of buff leather, and the bandouleer of the same, silver-laced; the hat was edged with broad silver lace. The horse-cloths and holster-caps were red, and the arms of the captain embroidered on the corners of the saddle-cloths, and on the front of the holsters.

In 1762, a considerable body of men was raised by order of Louis XV. The soldiers who composed it were called gensdarmes. And in 1792 the number was considerably augmented, consisting of horse and foot, and being discriminately called gensdarmes; but their clothing was altered to deep blue. Their pay was greater than what the rest of the army enjoyed; and when others were paid in paper currency, they received their subsistence in hard cash (en argent sonant). They possessed these privileges on account of the proofs they were obliged to bring of superior claims to military honour, before they could be enlisted as gensdarmes. It was necessary, in fact, that every individual amongst them should produce a certificate of six or eight years service.

GENDARMES (gens d'armes) de la garde, a select body of men so called during the old government of France, and still preserved in that country; but their services are applied to different purposes. They consisted originally of a single company which was formed by Henry IV. when he ascended the throne. He distinguished them from his other troops by styling them

hommes d'armes de ses ordonnances, men at arms under his own immediate orders. They consisted of men best qualified for every species of military duty, and were to constitute a royal squadron, at whose head the king himself personally engaged the enemy, as necessity might require. He gave this squadron to his son, the dauphin, who was afterwards king of France, under the name and title of Louis XIII.

GENDER, among grammarians, a division of nouns, or names, to distinguish the two sexes.

GENEALOGICA ARBOR, or tree of consanguinity, signifies a genealogy or lineage drawn out under the figure of a tree, with its root, stock, branches, &c. The genealogical degrees are usually represented in circles, ranged over, under, and aside each other. This the Greeks called stemmata, a word signifying crown, or garland.

GENEALOGY, an enumeration of a series of ancestors, or a summary account of the relations and alliances of a person or family, both in the direct and collateral line.

GENEPPA. See GARDENEA.

GENERAL, in a military sense, is an officer in chief, to whom the prince or senate of a country have judged proper to intrust the command of their troops. He holds this important trust under various titles: as captain-general, in England and Spain; feldt mareschal in Germany, or mareschal in France.

In the British service the king is constitutionally, and in his own proper right, captain-general. He has ten aid-de-camps; every one of whom enjoys the brevet-rank of full colonel in the army. Next to his majesty is the commander in chief, whom he sometimes honours with the title of captain-general. During the expedition to Holland, his royal highness the duke of York was entrusted with this important charge.

The natural qualities of a general are a martial genius, a solid judgment, a healthy robust constitution, intrepidity and presence of mind on critical occasions, indefatigability in business, goodness of heart, liberality, a reasonable age; if too young, he may want experience and prudence; if too old, he may not have vivacity enough. His conduct must be uniform, his temper affable, but inflexible in maintaining the police and discipline of an army.

The acquired qualities of a general should be secrecy, justice, sobriety, temperance, knowledge of the art of war from theory and practice, the art of commanding and speaking with precision and exactness, great attention to preserve the lives and supply the wants of the soldiers; and a constant study of the characters of the officers of his army, that he may employ them according to their talents. His conduct appears in establishing his magazines in the most convenient places; in examining the country, that he may not engage his troops too far, while he is ignorant of the means of bringing them off; in subsisting them, and in knowing how to take the most advantageous posts, either for fighting, retreating, or shunning a battle. His experience inspires his army with confidence, and an assurance of victory; and his quality, by creating respect, augments his authority. By his liberality he gets intelligence of the strength and designs of the enemy, and by this means is enabled to take the most successful measures. He ought to be fond of glory, to have an aversion to flattery, to render himself beloved, and to keep a strict discipline and regular subordination.

The office of a general is to regulate the march and encampment of the army; in the day of battle to chuse out the most advantageous ground; to make the disposition of the army; to post the artillery, and where there is occasion, to send his orders by his aid-de-camps. At a siege he is to cause the place to be invested, to regulate the approaches and attacks, to visit the works, and to send out detachments to secure the convoy and foraging parties.

GENERAL TERMS, among logicians, those which are made signs of general ideas.

GENERAL *of horse*, and GENERAL *of foot*, are posts next under the general of the army, and these have upon all occasions an absolute authority over all the horse and foot in the army.

GENERAL *of the artillery*, or *Master* GENERAL *of the ordnance*. See ORDNANCE.

GENERAL is also used for a particular march; or beat of drum, being the first which gives notice, commonly in the morning early, for the infantry to be in readiness to march.

GENERAL is also used for the chief of an order of monks; or of all the houses and congregations, established under the same rule. Thus we say, the general of the Franciscans, Cistercians, &c.

GENERALISSIMO, a supreme and absolute commander in the field. This word is generally used in most foreign languages. It was first invented by the absolute authority of carnidal Richelieu, when he went to command the French army in Italy.

GENERATING LINE OF FIGURE, in geometry, is that which by its motion produces any other plane or solid figure. Thus a right line moved any way parallel to itself, generates a parallelogram; round a point in the same plane, with one end fastened in that point, it generates a circle. One entire revolution of a circle, in the same plane, generates the cycloid; and the revolution of a semicircle round its diameter, generates a sphere.

GENERATION. See COMPARATIVE ANATOMY, and PHYSIOLOGY.

GENESIS, among mathematicians, signifies the formation or production of some figure or quantity.

GENEVA, or GIN, among distillers, an ordinary malt-spirit distilled a second time, with the addition of some juniper-berries. See DISTILLATION.

GENIOSTOMA, a genus of the monogynia order, in the pentandria class of plants. The calyx is a turbinated quinquefid perianthium; the corolla monopetalous and tubular; the stamina five short filaments; the antheræ oblong; the seeds very numerous and subangulated, placed on a filiform receptacle. There is one species, a native of the South Seas.

GENISTA, BROOM, or DYER'S-WEED, a genus of the decandria order, in the diadelphia class of plants, and in the natural method ranking under the 32d order, papilionaceæ. The calyx is bilabiate; the upper lip bidented, the under one tridentate; the vexillum is oblong and reflexed, or turned back from the pistil and stamina. There are 17 species, of which the most remarkable are the cytiso-genista, or common broom, and the tinctoria,

or dyer's-weed. The first is too well known to need description. Its young flowers are sometimes preserved as pickles; and the plant, when burnt, affords a tolerably pure alkaline salt. Dr. Mead relates the case of a dropsical patient that was cured by taking half a pint of a decoction of green broom-tops, with a spoonful of whole white mustard-seed, every morning and evening. The patient had been tapped three times, and tried the usual remedies before. The seeds, or an infusion of them drunk freely, have been known to produce similar happy effects; but these are to be expected in very few instances. Cows, horses, and sheep, refuse the plant. 2 The tinctoria is also a native of Britain. It rises with shrubby stalks three feet high, with spear-shaped leaves placed alternate, and terminated by several spikes of yellow flowers, succeeded by pods. The branches of the plant are used by dyers for giving a yellow colour; whence it is called dyer's-broom, green-wood, wood waxen, or dyer's-weed. A dram and half of the powdered seeds operates as a mild purgative. A decoction of the plant is diuretic, and, like the former, has proved serviceable in dropsical cases. Horses, cows, goats, and sheep, eat it.

GENITIVE, in grammar, the second case of the declension of nouns.

GENTIANA. Gentian, a genus of the digynia order, in the pentandria class of plants, and in the natural method ranking under the 20th order, rotaceæ. The corolla is monopetalous, the capsule bivalved and unilocular; there are two longitudinal receptacles. There are 53 species. The most remarkable are the following:

1. The lutea, or common gentian of the shops. This is a native of the mountainous parts of Germany, whence the roots, the only part used in medicine, are brought to this country. They have a yellowish-brown colour, and a very bitter taste. The lower leaves are of an oblong oval shape, a little pointed at the end, stiff, of a yellowish green, and have five large veins on the back of each. The stalk rises four or five feet high, with leaves growing by pairs at each joint, almost embracing the stalk at their base. They are of the same form with the lower, but diminish gradually in their size to the top. The flowers come out in whorls at the joints on the upper part of the stalks, standing on short footstalks, whose origin is in the wings of the leaves. They are of a pale-yellow colour. The roots of this plant are very frequently used in medicine as stomachic bitters. In taste they are less exceptionable than most of the substances of this class. Infusions of gentian-root flavoured with orange-peel are sufficiently grateful. Some years ago a poisonous root was discovered among the gentian brought to London, the use of which occasioned violent disorders, and in some cases death. This root is easily distinguished from the gentian, by its being internally of a white colour, and void of bitterness.

2. The centaureum, or lesser centaury of the shops, is a native of many parts of Britain. It grows on dry pastures, and its height is commonly proportioned to the goodness of the soil, as in rich soils it will grow to the height of a foot, but in poor ones not above three or four inches. It is an annual plant, with upright branching stalks, and small leaves, placed by pairs. The flowers grow in form of an umbel at the top of the stalk, and are of a bright purple colour. They come out in July, and the seed ripens in autumn. The plant cannot be cultivated in gardens. The tops are an useful aperient bitter, in which view they have been often used in the practice of medicine.

3. The acaulis, a beautiful little plant for the flower garden, conspicuous for its fine changeable azure blue flowers. It is a native of the Alps.

GENTILE, *gentilis*, in the Roman law and history, a name which sometimes expresses what the Romans otherwise called barbarians, whether they were allies of Rome or not: but this word was used in a more particular sense for all strangers and foreigners not subject to the Roman empire, in contradistinction to provincials, or an inhabitant of a province of the empire.

GENTLEMAN, according to sir Edward Coke, is one who bears coat-armour, the grant of which adds gentility to a man's family. 2 Inst. 667.

GENUS, among metaphysicians and logicians, denotes a number of beings, which agree in certain general properties, common to them all, so that a genus is nothing but an abstract idea, expressed by some general name or term.

Genus, in natural history, a subdivision of any class or order of natural beings, whether of the animal, vegetable, or mineral kingdoms; all agreeing in certain common characters.

Genus, in music, by the ancients called genus melodiæ, is a certain manner of dividing and subdividing the principles of melody, that is, the consonant and dissonant intervals, into their concinnous parts.

GEOCENTRIC, in astronomy, is applied to a planet or its orbit to denote it concentric with the earth, or as having the earth for its centre, or the same centre with the earth.

Geocentric *latitude of a planet,* is its distance from the ecliptic as it is seen from the earth, which even though the planet be in the same point of her orbit, is not constantly the same, but alters according to the position of the earth in respect to the planet.

Geocentric *place of a planet,* the place in which it appears to us from the earth, supposing the eye there fixed: or it is a point in the ecliptic to which a planet seen from the earth is referred.

GEOFFROYA, a genus of the decandria order, in the diadelphia class of plants, and in the natural method ranking under the 32d order, papilionaciæ. The calyx is quinquefid, the fruit an oval plum, the kernel compressed. There are two species; the intermis, or cabbage bark tree, is a native of Brasil and Jamaica. The wood of this tree is used in building; but it is chiefly valued for its bark, which is administered as an anthelmintic medicine. From this medical property it is also called the worm-bark tree. This bark is of a grey colour externally, but black and furrowed on the inside. It has a mucilaginous and sweetish taste, and a disagreeable smell. It is given in cases of worms, in form of powder, decoction, syrup, and extract. The decoction is preferred, and is made by slowly boiling an ounce of the fresh-dried bark in a quart of water, till it assumes the colour of Madeira wine. This, sweetened, is the syrup; evaporated, it forms an extract. It commonly produces some sickness and purging; sometimes violent effects, as

vomiting, delirium, and fever. These last are said to be owing to an over-dose, or to drinking cold water, and are relieved by the use of warm water, castor oil, or a vegetable acid. It should always be begun in small doses. But when properly and cautiously administered, it is said to operate as a very powerful anthelmintic, particularly for the explosion of the lumbrici, which are a very common cause of disease in the West Indies.

GEOGRAPHY, is a word derived from the Greek language, and implies a description of the earth. It is sometimes contrasted with hydrography, which signifies a description of the water, that is, of seas, lakes, rivers, &c. including marine charts. Anciently both were considered in connection with astronomy, as parts of cosmography; which attempted to delineate the universe. Geography is more justly contrasted with chorography, which illustrates a country or province; and still more with topography, which describes a particular place, or smaller district.

What is called general geography embraces a wide view of the subject; regarding the earth astronomically as a planet, the grand divisions of land and water, the winds, tides, meteorology, and may extend to what is called mechanical geography, including directions for the construction of globes, maps, and charts.

Among other divisions of this science may be named sacred geography, solely employed in the illustration of the scriptures; ecclesiastical geography, which describes the government of the church as divided into patriarchates, archbishopricks, bishopricks, archdeanries, &c. with their respective boundaries, which frequently vary much from those of the secular provinces; and physical geography, or geology which investigates the interior of the earth, so far only as real discoveries can be made. See GEOLOGY.

Geography, popularly considered, is occupied in the description of the various regions of this globe, chiefly as being divided among various nations, and improved by human art and industry.

GEOGRAPHY, *history of*. The study of geography being of so much practical importance in life, must have commenced in the early ages of the world. It was regarded as a science by the Babylonians and Egyptians, from whom it passed to the Greeks, and from these to the Romans, the Arabians, and the western nations of Europe. Thales of Miletus, in the 6th century before Christ, first made observations on the apparent progress of the sun from tropic to tropic; and is said to have written two treatises, the one on the tropic, and the other on the equinox, whence he was led to the discovery of the four seasons, which are determined by the equinoxes and solstices. We are assured this knowledge was obtained by means of the gnomon. Thales, it is also said, constructed a globe, and represented the land and sea upon a table of brass.

Meton and Euctemon observed the summer solstice at Athens, on the 27th of June, 432 years before Christ, by watching narrowly the shadow of the gnomon, with the design of fixing the beginning of their cycle of 19 years.

Timocharis and Aristillus, who began their observations about 295 B. C., first attempted to fix the latitudes and longitudes of the fixed stars, by considering their distances from the equator, &c. One of their observations gave rise to the discovery of the precession of the equinoxes, which was first remarked by Hipparchus about 150 years after; who also made use of their method for delineating the parallels of latitude and the meridians, on the surface of the earth; thus laying the foundation of this science as it now appears. See EQUINOXES, *precession of*.

The latitudes and longitudes, thus introduced by Hipparchus, were not however much attended to till Ptolemy's time. Strabo, Vitruvius, and Pliny, have all of them entered into a minute geographical description of the situation of places, according to the length of the shadows of the gnomon, without noticing the longitudes and latitudes.

Maps at first were little more than rude outlines, and topographical sketches of different countries. The earliest on record were those of Sesostris, mentioned by Eustathius, who says, that "this Egyptian king, having traversed great part of the earth, recorded his march in maps, and gave copies of them not only to the Egyptians, but to the Scythians, to their great astonishment." Some have imagined, with much probability, that the Jews made a map of the Holy Land when they gave the different portions to the nine tribes at Shiloh; for Joshua tells us that they were sent to walk through the land, and that they described it in seven parts in a book; and Josephus relates that when Joshua sent out people from the different tribes to measure the land, he gave them as companions persons well skilled in geometry, who could not be mistaken in the truth.

The first Grecian map on record was that of Anaximander, mentioned by Strabo, supposed to be that referred to by Hipparchus under the designation of the ancient map. Herodotus minutely describes a map made by Aristagoras, tyrant of Miletus, which will serve to give some idea of the maps of those times. He relates, that Aristagoras showed it to Cleomenes, king of Sparta, to induce him to attack the king of Persia at Susa, in order to restore the Ionians to their ancient liberty. It was traced upon brass or copper, and seems to have been a mere itinerary, containing the route through the intermediate countries which were to be traversed in that march, with the rivers Halys, the Euphrates, and Tigris, which Herodotus mentions as necessary to be crossed in that expedition. It contained one straight line called the royal road, or highway, which took in all the stations or places of encampment from Sardis to Susa; being 111 in the whole journey, and containing 13,500 stadia, or 1687½ Roman miles of 5000 feet each.

Eratosthenes first attempted to reduce geography to a regular system, and introduced a regular parallel of latitude, which began at the straits of Gibraltar, passed eastwards through the isle of Rhodes, and so on to the mountains of India, noting all the intermediate places through which it passed. In drawing this line, he was not regulated by the same latitude, but by observing where the longest day was 14 hours and a half, which Hipparchus afterwards determined was the latitude of 36 degrees.

This first parallel through Rhodes was ever after considered with a degree of preference, in constructing all the ancient maps; and the longitude of the then known

world was often attempted to be measured in stadia and miles, according to the extent of that line, by many succeeding geographers.

Eratosthenes soon after attempted not only to draw other parallels of latitude, but also to trace a meridian at right angles to these, passing through Rhodes and Alexandria down to Syene and Meroe; and at length he undertook the arduous task of determining the circumference of the globe, by an actual measurement of a segment of one of its great circles. To find the magnitude of the earth is indeed a problem which has engaged the attention of astronomers and geographers ever since the spherical figure of it was known. It seems Anaximander was the first among the Greeks who wrote upon this subject. Archytas of Tarentum, a Pythagorean, famous for his skill in mathematics and mechanics, also made some attempts in this way; and Dr. Long conjectures that these are the authors of the most ancient opinion that the circumference of the earth is 400,000 stadia; and Archimedes makes mention of the ancients who estimated the circumference of the earth at only 30,000 stadia.

As to the methods of measuring the circumference of the earth, it would seem, from what Aristotle says in his treatise De Cœlo, that they were much the same as those used by the moderns, deficient only in the accuracy of the instruments. That philosopher there says, that different stars pass through our zenith, according as our situation is more or less northerly; and that in the southern parts of the earth stars come above our horizon, which are no longer visible if we go northward. Hence it appears that there are two ways of measuring the circumference of the earth; one by observing stars which pass through the zenith of one place, and do not pass through that of another; the other, by observing some stars which come above the horizon of one place, and are observed at the same time to be in the horizon of another. The former of these methods, which is the best, was followed by Eratosthenes at Alexandria in Egypt, 250 years before Christ. He knew that at the summer solstice, the sun was vertical to the inhabitants of Syene, a town on the confines of Ethiopia, under the tropic of Cancer, where they had a well made to observe it, at the bottom of which the rays of the sun fell perpendicularly the day of the summer solstice: he observed by the shadow of a wire set perpendicularly in an hemispherical bason, how far the sun was on that day at noon distant from the zenith of Alexandria; when he found that distance was equal to the 50th part of a great circle in the heavens. Then supposing Syene and Alexandria under the same meridian, he inferred that the distance between them was the 50th part of a great circle upon the earth; and this distance being by measure 5000 stadia, he concluded that the whole circumference of the earth was 250,000 stadia. But as this number divided by 360 would give $694\frac{4}{9}$ stadia to a degree, either Eratosthenes himself, or some of his followers, assigned the round number 700 stadia to a degree, which multiplied by 360, makes the circumference of the earth 252,000 stadia; whence both these measures are given by different authors as that of Eratosthenes.

In the time of Pompey the Great, Posidonius determined the measure of the circumference of the earth by the 2d method above hinted by Aristotle, viz. the horizontal observations. Knowing that the star called Canopus was but just visible in the horizon of Rhodes, and at Alexandria finding its meridian height was the 48th part of a great circle in the heavens, or $7\frac{1}{2}$ deg. answering to the like quantity of a circle on the earth; then supposing these two places under the same meridian, and the distance between them 5000 stadia, the circumference of the earth will be 240,000 stadia; which is the first measure of Posidonius. But according to Strabo, Posidonius made the measure of the earth to be 180,000 stadia, at the rate of 500 stadia to a degree. The reason of this difference is thought to be, that Eratosthenes measured the distance between Rhodes and Alexandria, and found it only 3750 stadia; taking this for a 48th part of the earth's circumference, which is the measure of Posidonius, the whole circumference will be 180,000 stadia. This measure was received by Marinus of Tyre, and is usually ascribed to Ptolemy. But this measurement is subject to great uncertainty, both on account of the great refraction of the stars near the horizon, the difficulty of measuring the distance at sea between Rhodes and Alexandria, and by supposing those places under the same meridian, when they are really very different.

Several geographers afterwards made use of the different heights of the pole in distant places under the same meridian, to find the dimensions of the earth. About the year 800 the khalif Almemun had the distance measured between two places that were two degrees asunder, and under the same meridian, in the plains of Sinjar in the Red Sea; and the result was, that the degree at one time was found equal to 56 miles, and at another $56\frac{1}{3}$ or $56\frac{2}{3}$ miles.

The next attempt to find out the circumference of the earth was in 1525, by Fernelius, a learned philosopher of France. For this purpose he took the height of the pole at Paris, going thence directly northwards, till he came to the place where the height of the pole was one degree more than at that city. The length of the way was measured by the number of revolutions made by one of the wheels of his carriage; and after proper allowances for the declivities and turnings of the road, he concluded that 68 Italian miles were equal to a degree of the earth.

According to these methods many other measurements of the earth's circumference have since that time been made, with much greater accuracy: a particular account of which is give under the article DEGREE.

Though the maps of Eratosthenes were the best of his time, they were yet very imperfect and inaccurate. They contained little more than the states of Greece, and the dominions of the successors of Alexander, digested according to the surveys above-mentioned. He had indeed seen, and has quoted, the voyages of Pythias into the great Atlantic ocean, which gave him some faint ideas of the western part of Europe; but so imperfect, that they could not be realized into the outlines of a chart. Strabo says he was very ignorant of Gaul, Spain, Germany, and Britain; and he was equally ignorant of Italy, the coast of the Adriatic, Pontus, and all the countries towards the north.

Such was the state of geography, and the nature of the maps, before the time of Hipparchus. He made a closer

connection between geography and astronomy, by determining the latitudes from celestial observations.

War has usually been the occasion of making or improving the maps of countries; and accordingly geography made great advances from the progress of the Roman arms. In all the provinces occupied by that people, camps were every where constructed at proper intervals, and good roads made for communication between them; and thus civilization and surveying were carried on according to system through the whole extent of that empire. Every new war produced a new survey and itinerary of the countries where the scenes of action passed; so that the materials of geography were accumulated by every additional conquest. Polybius says, that at the beginning of the second Punic war, when Hannibal was preparing his expedition against Rome, the countries through which he was to pass were carefully measured by the Romans. And Julius Cæsar caused a general survey of the Roman empire to be made, by a decree of the senate. Three surveyors had this task assigned them, which they completed in 25 years. The Roman itineraries that are still extant, also shew what care and pains they had been at in making surveys in all the different provinces of their empire, and Pliny has filled the 3d, 4th, and 5th books of his Natural History with the geographical distances that were thus measured. Other maps are also still preserved, known by the name of the Pentigerian Tables, published by Welser and Bertius, which give a good specimen of what Vegetius calls the itinera picta, for the better direction of their armies in their march.

The Roman empire had been enlarged to its greatest extent, and all its provinces well known and surveyed, when Ptolemy, about 150 years after Christ, composed his system of geography. The chief materials he employed in composing this work, were the proportions of the gnomon to its shadow, taken by different astronomers at the times of the equinoxes and solstices; calculations founded on the length of the longest days; the measured or computed distances of the principal roads contained in their surveys and itineraries; and the various reports of travellers and navigators. All these were compared together, and digested into one uniform body or system; and afterwards were translated by him into a new mathematical language, expressing the different degrees of latitude and longitude, after the invention of Hipparchus, which had been neglected for 250 years.

Ptolemy's system of geography, notwithstanding it was still very imperfect, continued in vogue till the last three or four centuries, within which time the great improvements in astronomy, the many discoveries of new countries by voyagers, and the progress of war and arms, have contributed to bring it to a very considerable degree of perfection.

Principals of geography.

The fundamental principles of geography are, the spherical figure of the earth, its rotation on its axis, its revolution round the sun, and the position of the axis or line round which it revolves with regard to the celestial luminaries. That the earth and sea taken together constitute one vast sphere is demonstrable by the following arguments: 1. To people at sea the land disappears, though near enough to be visible was it not for the intervening convexity of the water. 2. The higher the eye is placed, the more extensive is the prospect; whence it is common for sailors to climb up to the tops of the masts to discover land or ships at a distance. But this would give them no advantage, was it not for the convexity of the earth; for upon an infinitely extended plane objects would be visible at the same distance whether the eye was high or low, nor would any of them vanish till the angle under which they appeared became too small to be perceived. 3. To people on shore, the mast of a ship at sea appears before the hull; but was the earth an infinite plane, not the highest object, but the largest, would be longest visible; and the mast of a ship would disappear, by the smallness of its angle, long before the hull did so. 4. The convexity of any piece of still water of a mile or two in extent may be perceived by the eye. A little boat, for instance, may be perceived by a man who is any height above the water; but if he stoops down or lays his eye near the surface, he will find that the fluid appears to rise and intercept the view of the boat entirely. 5. The earth has been often sailed round, as by Magellan, Drake, Dampier, Anson, Cook, and many other navigators, which demonstrates that the surface of the ocean is spherical; and that the land is very little different may easily be proved from the small elevation of any part of it above the surface of the water. The mouths of rivers which run 1000 miles are not more than one mile below their sources, and the highest mountains are not quite four miles of perpendicular height; so that, though some parts of the land are elevated into hills, and others depressed into valleys, the whole may still be accounted spherical. 6. An undeniable, and indeed ocular, demonstration of the spherical figure of the earth is taken from the round figure of its shadow which falls upon the moon in time of eclipses. As various sides of the earth are turned towards the sun during the time of different phenomena of this kind, and the shadow in all cases appears circular, it is impossible to suppose the figure of the earth to be any other than spherical. The inequalities of its surface have no effect upon the earth's shadow on the moon; for as the diameter of the terraqueous globe is very little less than 8000 miles, and the height of the highest mountains on earth not quite four, we cannot account the latter any more than the 2000th part of the former, so that the mountains bear no more proportion to the bulk of the earth, than grains of dust bear to that of a common globe.

A great many of the terrestrial phenomena depend upon the globular figure of the earth, and the position of its axis with regard to the sun, particularly the rising and setting of the celestial luminaries, the length of the days and nights, &c.

Though the sun rises and sets all over the world, the circumstances of his doing so are very different in different countries. The most remarkable of these circumstances is the duration of the light, not only of the sun himself, but of the twilight before he rises and after he sets. In the equatorial regions, for instance, darkness comes on very soon after sunset; because the convexity of the earth comes quickly in between the eye of the observer and the luminary, the motion of the earth being much more rapid there than any where else. In our climate the twilight always continues two hours, or thereabouts, and during the summer season it con-

tinues in a considerable degree during the whole night. In countries farther to the northward or southward, the twilight becomes brighter and brighter as we approach the poles, until at last the sun does not appear to touch the horizon, but goes in a circle at some distance above it for many days successively. In like manner, during the winter, the same luminary sinks lower and lower, until at last he does not appear at all; and there is only a dim twinkling of twilight for an hour or two in the middle of the day. By reason of the refraction of the atmosphere, however, the time of darkness, even in the most inhospitable climates, is always less than that of light; and so remarkable is the effect of this property, that in the year 1682, when some Dutch navigators wintered in Nova Zembla, the sun was visible to them 16 days before he could have been seen above the horizon, had there been no atmosphere. The reason of all this is, that in the northern and southern regions only a small part of the convexity of the globe is interposed betwixt us and the sun for many days, and in the high latitudes none at all. In the warmer climates the sun has often a beautiful appearance at rising and setting, from the refraction of his light through the vapours which are copiously raised in those parts. In the colder regions, halos, parhelia, aurora borealis, and other meteors, are frequent; the two former owing to the great quantity of vapour continually flying from the warm regions of the equator to the colder ones of the poles. In the high northern latitudes, thunder and lightnings are unknown, or but seldom heard of; but the more terrible phenomena of earthquakes, volcanoes, &c. are by no means unfrequent. These, however, seem only to affect islands and the maritime parts of the continent.

Notwithstanding the seeming inequality in the distribution of light and darkness, however, it is certain, that throughout the whole world there is nearly an equal proportion of light diffused on every part, abstracting from what is absorded by clouds, vapours, and the atmosphere itself. The equatorial regions have indeed the most intense light during the day, but the nights are long and dark; while, on the other hand, in the northerly and southerly parts, though the sun shines less powerfully, yet the length of time that he appears above the horizon, with the greater duration of the twilight, compensates for the seeming deficiency.

Was the earth a perfect plane, the sun would appear to be vertical in every part of it; for, in comparison with the immense magnitude of that luminary, the diameter of this globe itself is but very small; and as the sun, was he near to us, would do much more than cover the whole earth, so, though he was removed to any distance, the whole diameter of the latter would make no difference in the apparent angle of altitude. By means of the globular figure of the earth also, along with the great disparity between the diameters of the two bodies, some advantage is given to the day over the night; for thus the sun, being immensely the larger of the two, shines upon more than one-half of the earth; whence the unenlightened part has a shorter way to go before it again receives the benefit of his rays. This difference is greater in the inferior planets Venus and Mercury than in the earth.

To the globular figure of the earth likewise is owing the long moonlight which the inhabitants of the polar regions enjoy. The same thing likewise occasions the appearance and disappearance of certain stars at some seasons of the year in some countries; for, was the earth flat, they would all be visible in every part of the world at the same time. Hence most probably has arisen the opinion of the influence of certain stars upon the weather and other sublunary matters. In short, on the globular figure of the earth depends the whole present appearance of nature around us; and was the shape of the planet we inhabit to be altered to any other, besides the real differences which would of consequence take place, the apparent ones would be so great, that we cannot form any idea of the face which nature would then present to us. See ASTRONOMY.

In geography the circles which the sun apparently describes in the heavens are supposed to be extended as far as the earth, and marked on its surface; and in like manner we may imagine as many circles as we please to be described on the earth, and their planes to be extended to the celestial sphere, till they mark concentric ones on the heavens. The most remarkable of those supposed by geographers to be described in this manner are the following.

1. *The horizon*. This is properly a double circle, one of the horizons being called the sensible, and the other the rational. The former comprehends only that space which we can see around us upon any part of the earth, and which is very different according to the difference of our situation. The other, called the rational, is a circle parallel to the former, and passing through the centre of the earth, supposed to be continued as far as the celestial sphere itself. To the eyes of spectators there is always a vast difference between the sensible and rational horizons; but from the immense disparity betwixt the size of the earth and celestial sphere, planes of both circles may be considered as coincident. Hence in geography, when the horizon, or plane of the horizon, is spoken of, the rational is always understood when nothing is said to the contrary. In consequence of the round figure of the earth, every part has a different horizon. The poles of the horizon, that is, the points directly above the head, and opposite to the feet of the observer, are called the zenith and nadir.

2. A great circle described upon the sphere of the heaven, and passing through the two vertical points, is called a vertical circle, or an azimuth; and of these we may suppose as many as we please all round the horizon. In geography every circle obtains the epithet of great whose plane passes through the centre of the earth; in other cases they are called lesser circles. The altitudes of the heavenly bodies are measured by an arch of the azimuth or vertical circle intercepted between the horizon and the body itself. The most accurate method of taking them, with regard to the sun and moon, is for two persons to make their observations at the same time; one of them to observe the altitude of the upper limb, the other of the lower limb of the luminary; the mean betwixt these two giving the true height of the centre. The same thing may also be done accurately by one observer, having the apparent diameter of the luminary given. For, having found the height of the upper edge of the limb by the quadrant, take from it half his diameter, the remainder is the height of his centre; or having found the altitude

of his lower edge, add to it half the diameter, and the sum is the height of the centre as before. When the observations are made with a large instrument, it will be convenient to use a sextant, or sixth part of a circle, rather than a quadrant, as being less unwieldly.

3. Almucantars are circles supposed to be drawn upon the sphere parallel to the horizon, and grow less and less as they approach the vertical points, where they entirely vanish. The apparent distances betwixt any two celestial bodies are measured by supposing arches of great circles drawn through them, and then finding how many degrees, minutes, &c. of these circles are intercepted between them.

4. Sometimes the visible horizon is considered only with regard to the objects which are upon the earth itself, in which case we may define it to be a lesser circle on the surface of the earth, comprehending all such objects as are at once visible to us; and the higher the eye, the more is the visible horizon extended. It is most accurately observed, however, on the sea, on account of the absence of those inequalities which at land render the circle irregular; and for this reason it is called sometimes the horizon of the sea, and may be observed by looking through the sights of a quadrant at the most distant part of the sea then visible.

5. The equator is a great circle upon the earth, every part of which is equally distant from the poles or extremities of the imaginary line on which the earth revolves. In the sea-language it is usually called the line, and when people sail over it they are said to cross the line.

6. The meridian of any place is a great circle on the earth drawn through that place and both poles of the earth. It cuts the horizon at right angles, marking upon it the true north and south point; dividing also the globe into two hemispheres, called the eastern and western from their relative situation to that place and to one another. The poles divide the meridians into two semicircles, one of which is drawn through the place to which the meridian belongs, the other through that point of the earth which is opposite to the place. By the meridian of a place, geographers and astronomers often mean that semicircle which passes through the place, and which may therefore be called the geographical meridian. All places lying under this semicircle are said to have the same meridian; the semicircle opposite to this is called the opposite meridian. The meridians are thus immovably fixed to the earth as much as the places themselves on its surface, and are carried along with it in its diurnal rotation. When the geographical meridian of any place is, by the rotation of the earth, brought to point at the sun, it is noon or mid-day at that place; in which case, was the plane of the circle extended, it would pass through the middle of the luminary's disk. Supposing the plane of the meridians to be extended to the sphere of the fixed stars, in that case, when by the rotation of the earth the meridian comes to any point in the heavens, then, from the apparent motion of the heavens, that point is said to come to the meridian. The rotation of the earth is from west to east; whence the celestial bodies appear to move the contrary way. East and west, however, are terms merely relative, since a place may be west from one part of the earth, and east from another; but the true east and west points from any place are those where its horizon cuts the equator.

7. All places lying under the same meridian are said to have the same longitude, and those which lie under different meridians to have different longitudes; the difference of longitude being reckoned eastward or westward on the equator. Thus, if the meridian of any place cuts the equator in a point 15 degrees distant from one another, we say there is a difference of 15° longitude betwixt these two places. Geographers usually fix upon the meridian of some remarkable place for the first meridian, and reckon the longitude of all others by the distance of their meridians from which they have determined upon as the first; measuring sometimes eastward on the equator all round the globe, or sometimes only one-half east and the other west; according to which last measurement no place can have more than 180° longitude either east or west. By the ancient Greek geographers the first meridian was placed in Hera or Junonia, one of the Fortunate Islands, as they were then called, which is supposed to be the present island of Teneriffe, one of the Canaries. These islands, being the most westerly part of the earth then known, were on that account made the seat of the first meridian, the longitude of all other places being counted eastward from them. Among modern geographers indeed, it is now become customary for each to make the first meridian pass through the capital of his own country; a practice, however, which is certainly improper, as it is thus impossible for the geographers of one nation to understand the maps of another without a troublesome calculation, which answers no purpose. By the British geographers the royal observatory at Greenwich is accounted the place of the first meridian.

8. If we suppose 12 great circles, one of which is the meridian to a given place, to intersect each other at the poles of the earth, and divide the equator into 24 equal parts, these are the hour-circles of that place. These are by the poles divided into 24 semicircles, corresponding to the 24 hours of the day and night. The distance betwixt each two of these semicircles is 15°, being the 24th part of 360; and by the rotation of the earth each succeeding semicircle points at the sun one hour after the preceding: so that in 24 hours all the semicircles point successively at the sun. Hence it appears, that such as have their meridian 15° east from any other have likewise noon one hour sooner, and the contrary; and in like manner every other hour of the natural day is an hour sooner at the one place than at the other. Hence, from any instantaneous appearance in the heavens observed at two distant places, the difference of longitude may be found, if the hour of the day is known at each place. Thus the beginning of an eclipse of the moon, when the luminary first touches the shadow of the earth, is an instantaneous appearance, as also the end of an eclipse of this kind, when the moon leaves the shadow of the earth visible to all the inhabitants on that side of the globe. If therefore we find, that at any place an eclipse of the moon begins an hour sooner than at another, we conclude that there is a difference of 15° of longitude between the two places. Hence also was a man to travel or sail round the world from west to east, he would reckon one day more to have passed than they do who stay at the place

whence he set out; so that their Monday would be his Tuesday, &c. On the other hand, if he sails westward, he will reckon a day less, or be one day in the week later, than those he leaves behind.

9. The equator divides the earth into two hemispheres, called the northern and southern; all places lying under the equator are said to have no latitude; and all others to have north or south latitude, according to their situation with respect to the equator. The latitude itself is the distance from the equator measured upon the meridian, in degrees, minutes, and seconds. The complement of latitude is the difference between the latitude itself and 90°, or as much as the place itself is distant from the pole; and this complement is always equal to the elevation of the equator above the horizon of the place. The elevation of the pole of any place is equal to the latitude itself.

An inhabitant of the earth who lived (if it was possible) at either of the poles would have always one of the celestial poles in his zenith, and the other in his nadir, the equator coinciding with the horizon. Hence all the celestial parallels are also parallel to the horizon; whence the person is said to live in a parallel sphere, or to have a parallel horizon.

Those who live under the equator have both poles in the horizon, all the celestial parallels cutting the horizon at right angles; whence they are said to live in a right sphere, or to have a right horizon.

Lastly, those who live between either of the poles and the equator, are said to live in an oblique sphere, or to have an oblique horizon, because the celestial equator cuts their horizon obliquely, and all the parallels in the celestial sphere have their planes oblique to that of the horizon. In this sphere some of the parallels intersect the horizon at oblique angles, some are entirely above it; and some are entirely below it; all of them, however, so situated, that they would obliquely intersect the plane of the horizon extended.

The largest parallel which appears entire above the horizon of any place in north latitude is called by the ancient astronomers the arctic circle of that place; within this circle, that is, between it and the arctic pole, are comprehended all the stars which never set in that place, but are carried perpetually round the horizon in circles parallel to the equator. The largest parallel which is hid entirely below the horizon of any place in north latitude was called the antarctic circle of that place by the ancients. This circle comprehends all the stars which never rise in that place, but are carried perpetually round below the horison in circles parallel to the equator. In a parallel sphere, however, the quator may be considered as both arctic and antarctic circle; for, being coincident with the horizon, all the parallels on one side are entirely above it, and those on the other entirely below it. In an oblique sphere, the nearer any place is to either of the poles, the larger are the arctic and antarctic circles, as being nearer to the celestial equator, which is a great circle. In a right sphere, the arctic and antarctic circles have no place, because no parallel appears either entirely above or below it. By the arctic and antarctic circles, however, modern geographers in general understand two fixed circles at the distance of 23½ degrees from the pole. These are supposed to be described by the poles of the ecliptic, and mark out the space all round the globe where the sun appears to touch the horizon at midnight in the summer time, and to be entirely sunk below it in the winter. These are also called the polar circles.

According to the different positions of the globe with regard to the sun, the celestial bodies will exhibit different phenomena to the inhabitants. Thus, in a parallel sphere, they will appear to move in circles round the horizon; in a right sphere they would appear to rise and set as at present, but always in circles, cutting the horizon at right angles; but in an oblique sphere the angle varies according to the degree of obliquity, and the position of the axis of the sphere with regard to the sun. Hence we easily perceive the reason of the sun's continual change of place in the heavens; but though it is certain that this change takes place every moment, the vast distance of the luminary renders it imperceptible for some time, unless to very nice astronomical observers. Hence we may generally suppose the place of the sun to be the same for a day or two together, though in a considerable number of days it becomes exceedingly obvious to every body. When he appears in the celestial equator, his motion appears for some time to be in the plane of that circle, though it is certain that his place there is only for a single moment; and in like manner, when he comes to any other point of the heavens, his apparent diurnal motion is in a parallel drawn throughout. Twice a year he is in the equator, and then the days and nights are nearly equal all over the earth. This happens in the months of March and September; after which the sun proceeding either northward or south, according to the season of the year and the position of the observer, the days become longer or shorter than the nights, and summer or winter comes on, as is fully explained under the article ASTRONOMY. The secession of the sun from the equator either northward or southward is called his declination, and is either north or south according to the season of the year; and when this declination is at its greatest height, he is then said to be in the tropic, because he begins to turn back (the word tropic being derived from the Greek τρεπω, verto.) The space between the two tropics, called the torrid zone, extends for no less than 47 degrees of latitude all round the globe; and throughout the whole of that space the sun is vertical to some of the inhabitants twice a year, but to those who live directly under the tropics only once. Throughout the whole torrid zone also there is little difference between the length of the days and nights. The ancient geographers found themselves considerably embarrassed in their attempts to fix the northern tropic; for though they took a very proper method, namely, to observe the most northerly place where objects had no shadow on a certain day, yet they found that on the same day no shadow was cast for a space of no less than 300 stadia. The reason of this was, the apparent diameter of the sun, which, being about half a degree, seemed to extend himself over as much of the surface of the earth, and to be vertical every where within that space.

When the sun is in or near the equator, he seems to change his place in the heavens most rapidly; so that about the equinoxes one may very easily perceive the difference in a day or two; but as he approaches the tropics,

this apparent change becomes gradually slower, so that for a number of days he scarcely seems to move at all. The reason of this may easily be understood from any map on which the ecliptic is delineated; for by drawing lines through every degree of it parallel to the equator, we shall perceive them gradually approach nearer and nearer each other, until at last, when we approach the point of contact betwixt the ecliptic and tropic, they can for several degrees scarcely be distinguished at all.

From an observation of the diversity in the length of the days and nights, the rising and setting of the sun, with the other phenomena already mentioned, the ancient geographers divided the surface of the earth into certain districts, which they called climates; and instead of the method of describing the situation of places by their latitude and longitude as we do now, they contented themselves with mentioning the climate in which they were situated.

This method of dividing the surface of the earth into climates, though now very much disused, has been adopted by several modern geographers. Some of these begin their climates at the equator, reckoning them by the increase of half an hour in the length of the day northward. Thus they go on till they come to the polar circles, where the longest day is 24 hours: betwixt these and the poles they count the climates by the increase of a natural day in the length of time that the sun continues above the horizon, until they come to one where the longest day is 15 of ours, or half a month; and from this to the pole they count by the increase of half-months or whole months, the climates ending at the poles where the days are six months long. The climates betwixt the equator and the polar circles are called hour-climates, and those between the polar circles and the poles are called month-climates. In common language, however, we take the word climate in a very different sense; so that when two countries are said to be in different climates, we understand only that the temperature of the air, seasons, &c. are different.

From the difference in the length and positions of the shadows of terrestrial substances, ancient geographers have given different terms to the inhabitants of certain places of the earth; the reason of which will be easily understood from the following considerations: 1. Since the sun in his apparent annual revolution never removes farther from the equator than $23\frac{1}{2}$ degrees, it follows, that none of those who live without that space, or beyond the tropics, can have the luminary vertical to them at any season of the year. 2. All who live between the tropics have the sun vertical twice a year, though not all at the same time. Thus, to those who live directly under the equator, he is directly vertical in March and September at the time of the equinox. If a place is in 10° north latitude, the sun is vertical when he has 10° north declination, and so of every other place. 3. All who live between the tropics have the sun at noon sometimes north and sometimes south of them. Thus those who live in a place situated in 20° north latitude have the sun at noon to the northward when he has more than 20 degrees north declination, and to the southward when he has less. 4. Such of the inhabitants of the earth as live without the tropics, if in the northern hemisphere, have the sun at noon to the southward of them, but to the northward if in the southern hemisphere. 1. Hence when the sun is in the zenith of any place, the shadow of a man or any upright object falls directly upon the place where they stand, and consequently is invisible; whence the inhabitants of such places were called Ascii, or without shadows. 2. Those who live between the tropics, and have the sun sometimes to the north and sometimes to the south of them, have of consequence their shadows projecting north at some seasons of the year, and south at others, whence they were called Amphiscii, or having two kinds of shadows. 3. Those who live without the tropics have their noon-shadows always the same way, and are therefore called Heteroscii, that is, having only one kind of shadow. If they are in north latitude, the shadows are always turned towards the north, and if in the southern hemisphere, towards the south. 4. When a place is so far distant from the equator that the days are 24 hours long, or longer, the inhabitants were called Periscii, because their shadows turn round them.

Names have likewise been imposed upon the inhabitants of different parts of the earth from the parallels of latitude under which they live, and their situation with regard to one another. 1. Those who lived at distant places, but under the same parallel, were called Periæci, that is, living in the same circle. Some writers, however, by the name of Periæci distinguish those who live under opposite points of the same parallel, where the noon of one is the midnight of the other. 2. When two places lie under parallels equally distant from the equator, but in opposite hemispheres, the inhabitants were called Antæci. These have a similar increase of days and nights, and similar seasons, but in opposite months of the year. According to some, the Antæci were such as lived under the same geographical meridian, and had day and night at the same time. 3. If two places are in parallels equally distant from the equator, and in opposite meridians, the inhabitants were called Antipodes, that is, having their feet opposite to one another. When two persons are Antipodes, the zenith of the one is the nadir of the other. They have a like elevation of the pole, but it is of different poles; they have also days and nights alike, and similar seasons of the year, but they have opposite hours of the day and night, as well as seasons of the year. Thus, when it is mid-day with us, it is midnight with our Antipodes; when it is summer with us, it is winter with them, &c.

From the various appearances of the sun, and the effects of his light and heat upon different parts of the earth, the division of it into zones has arisen. These are five in number. 1. The torrid zone, lying between the two tropics for the space of 47° of latitude. This is divided into two equal parts by the equator. 2. The two temperate zones lie between the polar circles and the tropics, containing a space of 43° of latitude. And, 3. The two frigid zones lie between the polar circles and the poles. In these last the longest day is never below 24 hours; in the temperate zones it is never quite so much, and in the torrid zone it is never above 14. The zones are named from the degree of heat they were supposed to be subjected to. The torrid zone was supposed by the ancients to be uninhabitable, on account of its heat; but this is now found to be a mistake, and many parts of the temperate zones are more intolerable in this respect than

the torrid zone itself. Towards the polar circles also these zones are intolerably cold during the winter season. Only a small part of the northern frigid zone, and none of the southern, is inhabited. Some geographers reckoned six zones, dividing the torrid zone into two by the equator.

Besides these there are other technical terms belonging to geography which it is necessary to explain; some of these have relation to the earth, and others to the water.

A *continent* is a large portion of the earth, which comprehends several countries that are not separated by any sea; such are Europe, Asia, Africa, and America. An *island* is a part of the earth which is entirely surrounded by water; as Great Britain. A *peninsula* is a tract of land almost surrounded with water, and is joined to a continent only by a narrow slip or neck; such is the Morea in Greece. An *isthmus*, or neck of land, is that part by which a peninsula is joined to a continent, or two continents together; as the isthmus of Suez, which joins Africa to Asia. A *promontory*, or cape, is a high part of land which stretches into the sea; thus the Cape of Good Hope is a promontory. An *ocean* is a vast collection of waters surrounding a considerable part of the continent; as the Atlantic. A *sea* is a smaller collection of waters; as the Black Sea. A *gulf* is a part of the sea which is nearly surrounded with land; as the gulf of Venice. A *bay* has a wider entrance than a gulf; as the Bay of Biscay. A *strait* is a narrow passage that joins two seas; as the Strait of Gibraltar, which joins the Mediterranean to the Atlantic. A *lake* is a large collection of water entirely surrounded by land, having no visible communication with the sea; as the Caspian Lake in Asia. A *river* is a stream of water that has its source from a spring, which keeps constantly running till it falls into some other river, or into the sea.

In a popular point of view, geography admits of three divisions: 1. The ancient or classical, which describes the state of the earth, not extending farther than the 500th year of the Christian æra. 2. That of the middle ages, which reaches to the 15th century, when the discoveries of the Portuguese began to lay broader foundations for this science. 3. Modern geography, the chief object of which is to present the most recent and authentic information concerning the nations and states which divide and diversify the earth. In some instances natural barriers have divided, and continue to divide, nations; but in general the boundaries are arbitrary, so that the natural geography of a country may be regarded as a sequel to the science, which is chiefly occupied in describing the diversities of nations, and the conditions of the various races of mankind.

The ancients considered the globe under the three grand divisions of Asia, Europe, and Africa. Here the distinctions were arbitrary, as they often included Egypt under Asia, and they had not discovered the limits of Europe towards the N. E. Modern discoveries have added a fourth division, that of America, which exceeding even Asia in size, might have been admitted under two grand and distinct denominations, limited by the isthmus of Darien. Till within these last 30 years it was supposed that a vast continent existed in the south of the globe; but the second navigation of Capt. Cook dispelled the idea, and demonstrated, that if any continent existed there, it must be in the uninhabitable ice of the south pole. The vast extent of New Holland rewarded the views of enterprise; this, which seems too large to be ranked among islands, and two small for a continent, eludes the petty distinctions of man: and while geographers hesitate whether to ascribe it to Asia, or to denominate it a fifth specific division of the earth, it is not improbable that the popular division of four quarters will still predominate over all speculative discussions.

Of the grand divisions of the earth, Asia has ever been esteemed the most populous; and is supposed to contain five hundred millions of souls, if China, as has been averred by the latest writers, comprizes three hundred and thirty millions. The population of Africa may be estimated at thirty millions, of America at thirty millions, and one hundred and sixty millions may perhaps be assigned to Europe.

Modern discoveries have evinced that more than two thirds of the globe is covered with water, which is contained in hollow spaces, or concavities, more or less large. But the chief convexities or protuberances of the globe consist of elevated uplands, sometimes crowned by mountains, sometimes rather level, as the extensive protuberance of Asia. In either case, long chains of mountains commonly proceed from those chief convexities in various directions, and the principal rivers usually spring from the most elevated grounds.

The grandest concavity of this globe is filled by the Pacific Ocean; occupying nearly half its surface from the eastern shores of New Holland, to the western coast of America, and diversified with several groups of islands, which seem in a manner the summits of vast mountains emerging from the waves. This ocean receives but few rivers, the chief being the Amur from Tartary, the Hoan Ho and Kian Ku from China, while the principal rivers of America run towards the east.

Next to this in magnitude is the Atlantic, between the Old and New Continents; and the third is the Indian Ocean. The seas between the arctic and antarctic circles and the poles, have been sometimes styled the Arctic and Antarctic Oceans; but the latter is only a continuation of the Pacific, Atlantic, and Indian Oceans; while the Arctic Sea is partly embraced by continents, and receives many important rivers. Besides these, there are other seas more minute, as the Mediterranean, the Baltic, and others still smaller, till we come by due gradation to inland lakes of fresh water.

The courses of rivers are sometimes marked by oblong concavities, which generally at first intersect the higher grounds, till the declivity becomes more gentle on their approach towards their inferior receptacles. But even large rivers are found sometimes to spring from lowland marshes, and wind though vast plains, unaccompanied by any concavity, except that of their immediate course; while on the other hand, extensive vales, and low hollow spaces, frequently occur destitute of any stream. Rivers will also sometimes force a passage where nature has erected mountains and rocks against it, and where the concavity would appear to be in another direction, which the river might have gained with more ease. In like manner, though the chief mountains of Europe extend in a south-easterly direction, yet there are so many exceptions, and such numerous and impor-

tant variations in other parts of the globe, as to render any attempt at general theory vain.

From the vast expanse of oceanic waters, arises in the ancient hemisphere, that wide continent, which contains Asia, Europe, and Africa; and in the modern hemisphere the continent of America, which forms a kind of separate island, divided by a strait of the sea from the ancient continent. In the latter many discoveries of great importance to geography, are of very modern date, and it is not above 60 years since we obtained an imperfect idea of the extent of Siberia and the Russian empire, nor above 25 since ample, real, and accurate knowledge of these wide regions began to be diffused. So that, in truth, America may be said to have been discovered before Asia; and of Africa our knowledge continues imperfect, while the latest observations, instead of diminishing, rather increase our idea of its extent.

But the grandest division of the ancient continent is Asia, the parent of nations, and of civilization: on the north-east and south, surrounded by the ocean; but on the west, divided by an ideal line from Africa; and from Europe by boundaries not very strongly impressed by the hand of nature. The Russian and the Turkish empires, extending over large portions of both continents, intimately connect Asia with Europe. But for the sake of clearness and precision, geographers retain the strict division of the ancient continent into three parts, which, if not strictly natural, is ethical, as the manners of the Asiatic subjects of Russia, and even of Turkey, differ considerably from those of the European inhabitants of those empires.

A description of the four quarters of the globe, and of the several kingdoms and states into which they are divided, belongs rather to a work devoted exclusively to geography, than to a dictionary of arts and sciences: we shall therefore forbear entering more into detail in this article.

GEOLOGY, a science which treats of the decomposition and changes to which the stony part of our globe has been subjected.

If it was permitted to man to follow, during several ages, the various changes which are produced on the surface of our globe by the numerous agents that alter it, we should at this time have been in possession of the most valuable information respecting these great phenomena: but thrown as we are, almost by accident, upon a small point of this vast theatre of observation, we fix our attention for a moment upon operations which have been the work of nature for ages; and we are unable either to perceive or to foretel the results, because several ages are scarcely sufficient to render the effects or changes perceptible.

It must be allowed that those men who, by the mere efforts of their imagination, have endeavoured to form ideas respecting the construction, and the great phenomena, of this globe, have numerous titles to our indulgence. In their proceedings we behold the efforts of genius, tormented with the desire of acquiring knowledge, and irritated at the prospect of the scanty means which nature has put in its power; and when these naturalists, such as M. de Buffon, have possessed the power of embellishing their hypotheses with every ornament which imagination and eloquence can furnish, either as instruments of illusion or entertainment, we ought to consider ourselves indebted to them.

For our part, we shall confine ourselves to a few ideas respecting the successive decompositions of our planet, and shall endeavour to avoid every departure from observation and matter of fact.

The slightest observation shows us that living beings are kept up and perpetuated only by successive decompositions and combinations. A slight view of the mineral kingdom exhibits the same changes; and our globe, in all its productions, presents continual modifications, and a circle of activity, which might appear incompatible with the apparent inertia of earthy products.

In order to arrange our ideas with greater regularity, we may consider this globe in two different states. We shall first examine the primitive rock which forms the nodule or central part. This appears to contain no germ of life; includes no remains or part of any living being; and from every circumstance appears to have been of primitive formation, anterior to the creation of animated or vegetating bodies. We shall pursue the various changes which are daily produced by the destructive action of such agents as alter or modify this substance.

We shall then proceed to examine what stones have been successively placed upon this, and what are the decompositions to which these secondary rocks have been subjected.

1. The observations of naturalists all unite to prove that the primitive part of the globe consists of the stone known by the name of granite. The profound excavations which the art of man, or currents of water, have made in the surface of our planet, have all uncovered this rock, and have been incapable of penetrating lower: we may therefore consider this substance as the nucleus of the globe; and upon this substance it is that all matters of posterior formation rest.

Granite exhibits many varieties in its form, composition, and disposition: but it in general consists of an assemblage of certain siliceous stones, such as quartz, schorl, feldtspar, mica, &c.; and the more or less considerable magnitude of these elements of granite, has caused it to be divided into coarse-grained granite, and fine-grained granite.

It is thought that these rocks owe their arrangement to water; and if we may be permitted to recur, by an effort of the imagination, to that epocha in which, according to sacred and profane historians, the water and earth were confounded, and the confused mixture of all principles formed a choas, we shall see that the laws of gravity inherent in matter must have carried it down, and necessarily produced the arrangement which observation at present exhibits to us. The water, as the least heavy, must have purified itself, and arisen to the surface by a filtration through the other materials: while the earthy principles must have precipitated, and formed a mud, in which all the elements of stones were confounded. In this very natural order of things, the general law of affinities, which continually tends to bring together all analogous parts, must have exerted itself with its whole activity upon the principles of this almost fluid paste; and the result have been a number of bodies of a more definite kind, in crystals more or less regular; and from this muddy substance, in which the principles of the stones

were confounded that compose the granite, a rock must have been produced, containing the elementary stones, all in possession of their distinct forms and characters. In this manner it is that we observe salts of very different kinds develope themselves in waters which hold them in solution; and in this manner it still happens that crystals of spar and gypsum are formed in clays which contain their component parts.

It may easily be conceived that the laws of gravitation must have influenced the arrangement and disposition of the products. The most gross and heavy bodies must have fallen, and the lightest and most attenuated substances must have arranged themselves on the surface of the foregoing; and this it is which constitutes the primitive schisti, the gneis, the rocks of mica, &c. which commonly repose upon masses of coarse-grained granite.

The disposition of the fine-grained granite in strata or beds, appears to depend on this position, and the fineness or tenuity of its parts. Being placed in immediate contact with water, this fluid must naturally have influenced the arrangement which it presents to us; and the elements of this rock being subjected to the effect of waves, and the action of currents, must have formed strata.

The rocks of granite being once established as the nucleus of our globe, we may, from the analysis of its constituent principles, and by attending to the action of the various agents capable of altering it, follow the changes to which it has been subjected, step by step.

Water is the principal agent whose effects we shall examine.

This fluid, collected in the cavity of the ocean, is carried by the atmosphere to the tops of the most elevated mountains, where it is precipitated in rain, and forms torrents, which return with various degrees of rapidity into this common reservoir.

This uninterrupted motion and fall must gradually attenuate and wear away the hardest rocks, and carry their detached parts to distances more or less considerable. The action of the air, and the varying temperature of the atmosphere, facilitate the attenuation and the destruction of these rocks. Heat acts upon their surface, and renders it more accessible and more penetrable to the water which succeeds; cold divides them, by freezing the water which has entered into their texture; the air itself affords the acid principle, which attacks the limestone, and causes it to effloresce; the oxygen unites to the iron, and calcines it: insomuch that this concurrence of causes favours the disunion of principles; and consequently the action of water, which clears the surface, carries away the products of decomposition, and makes preparation for a succeeding process of the same nature.

The first effect of the rain is therefore to depress the mountains. But the stones which compose them must resist in proportion to their hardness; and we ought not to be surprised when we observe peaks which have braved the destructive action of time, and still remain to attest the primitive level of the mountains which have disappeared. The primitive rocks, alike inaccessible to the injury of ages as to the animated beings which cover less elevated mountains with their remains, may be considered as the source or origin of rivers and streams. The water which falls on their summits, flows down in torrents by their lateral surfaces. In its course it wears away the soil upon which it incessantly acts. It hollows out a bed, of a depth proportioned to the rapidity of its course, the quantity of its waters, and the hardness of the rock over which it flows; at the same time that it carries along with it portions and fragments of such stones as it loosens in its course.

These stones, rolled along by the water, must strike together, and break off their projecting angles: a process that must quickly have afforded those rounded flints which form the beds of rivers. These pebbles are found to diminish in size, in proportion to the distance from the mountain which affords them; and it is to this cause that Mr. Dorthes has referred the disproportionate magnitude of the pebbles which form our ancient worn stones, when compared with those of modern date; for the sea extending itself formerly much more inland, in the direction of the Rhone, the stones which it received from the rivers, and threw back again upon the shores, had not run through so long a space in their beds as those which they at present pass over. Thus it is that the remains of the Alps, carried along by the Rhone, have successively covered the vast interval comprised between the mountains of Dauphiny and Vivaris; and are carried into seas, which deposit them in small pebbles on the shore.

The pulverulent remains of mountains, or the powder which results from the rounding of these flints, are carried along with greater facility than the flints themselves: they float for a long time in the water, whose transparency they impair; and when these same waters are less agitated, and their course becomes slackened, they are deposited in a fine and light paste, forming beds more or less thick, and of the same nature as that of the rocks to which they owe their origin. These strata gradually become drier by the agglutination of their principles; they become consistent, acquire hardness, and form silecious clays, silex, petrosilex, and all the numerous class of pebbles which are found dispersed in strata, or in banks, in the ancient beds of rivers.

The mud is much more frequently deposited in the interstices left between the rounded flints themselves, which intervals it fills, and there forms a true cement that becomes hard, and constitutes the compound stones known by the name of pudding-stones and grit-stones; for these two kinds of stones do not appear to differ but in the coarseness of the grain which forms them, and the cement which connects them together.

We sometimes observe the granite spontaneously decomposed. The texture of the stones which form it has been destroyed; the principles or component parts are disunited and separated, and they are gradually carried away by the waters.

Water filtrating through mountains of primitive rock, frequently carries along with it very minutely divided particles of quartz; and proceeds to form, by deposition, stalactites, agates, rock crystal, &c.

These quartzose stalactites, differently coloured, are of a formation considerably analogous to that of calcareous alabasters; and we perceive no other difference between them than that of their constituent parts.

II. Thus far we have exhibited, in a few words, the principal changes, and various modifications, to which the primitive rocks have been subjected. We have not yet observed either germination or life; and the metals.

sulphur, and bitumens, have not hitherto presented themselves to our observation. Their formation appears to be posterior to the existence of this primitive globe; and the alterations and decompositions which now remain to be inquired into, appear to be produced by the class of living, or organized beings.

On the one hand, we behold the numerous class of shell animals, which cause the stony mass of our globe to increase by their remains. The spoils of these creatures, long agitated and driven about by the waves, and more or less altered by collision, form those strata and banks of limestone, in which we very often perceive impressions of those shells to which they owe their origin.

On the other hand, we observe a numerous quantity of vegetables that grow and perish in the sea; and these plants likewise, deposited and heaped together by the currents, form strata, which are decomposed, lose their organization, and leave all the principles of the vegetable confounded with the earthy principle. It is to this source that the origin of pit-coal, and secondary schistus, is usually attributed; and this theory is established on the existence of the texture of decomposed vegetables very usually seen in schisti and coal, and likewise on the presence of shells and fish in most of these products.

It appears that the formation of pyrites ought in part to be attributed to the decomposition of vegetables: it exists in greater or less abundance in all schisti and coal. A wooden shovel has been found buried in the depositions of the river De Ceze, converted into jet and pyrites. The decomposition of animal substances may be added to this cause; and it appears to be a confirmation of these ideas, that we find many shells passed to the state of pyrites.

Not only the marine vegetables form considerable strata by their decomposition; but the remains of those which grow on the surface of the globe ought to be considered among the causes or agents which concur in producing changes upon that surface.

We shall separately consider how much is owing to each of these causes; and shall follow the effects of each, as if that cause alone was employed in modifying and altering our planet.

1. The secondary calcareous mountains are constantly placed upon the surface of the primitive mountains; and though a few solitary observations present a contrary order, we ought to consider this inversion and derangement as produced by shocks which have changed the primitive disposition. It must be observed also, that the disorder is sometimes merely apparent; and that some naturalists of little information have described calcareous mountains as inclining beneath the granite, because this last pierces through the envelope, rises to a greater height, and leaves at its feet, almost beneath it, the calcareous remains deposited at its base.

Sometimes even the limestone fills to a very great depth the crevices or clefts formed in the granite. The writer of this article has seen in Gevaudan, towards Florac, a profound cavity in the granite filled with calcareous stone. This vein is known to possess a depth of more than 150 fathoms, with a diameter of about two or three.

It likewise happens frequently enough that such waters as are loaded with the remains of the primitive granite, heap them together, and form secondary granites, which may exist above the calcareous stone.

The secalcareous mountains are decomposed by the combined action of air and water; and the product of their decomposition sometimes forms chalk or marle.

The lightness of this earth renders it easy to be transported by water; and this fluid, which does not possess the property of holding it in solution, soon deposits it in the form of gurhs, alabasters, stalactites, &c. Spars owe their formation to no other cause. Their crystallization is posterior to the origin of calcareous mountains.

Waters wear down and carry away calcareous mountains with greater ease than the primitive mountains: their remains being very light, are rolled along, and more or less worn. The fragments of these rocks are sometimes connected by a gluten or cement of the same nature; from which process calcareus grit and breccias arise. These calcareous remains formerly deposited themselves upon the quartzose sand; and the union of primitive matter, and secondary products, gives rise to a rock of mixed nature.

2. The mountains of secondary schistus frequently exhibit to us a pure mixture of earthy principles, without the smallest vestige of bitumen. These rocks afford, by analysis, silex, alumina, magnesia, lime in the state of carbonate, and iron: principles which are more or less united, and consequently accessible in various degrees to the action of such agents as destroy the rocks hitherto treated of.

The same principles, when disunited, and carried away by waters, give rise to a great part of the stones which are comprised in the magnesian class. The same elements, worn down by the waters, and deposited under circumstances proper to facilitate crystallization, form the schorls, tourmaline, garnets, &c.

We do not pretend by this to exclude and absolutely reject the system of such naturalists as attribute the formation of magnesian stones to the decomposition of the primitive rocks. But we think that this formation cannot be objected to for several of them, more especially such as contain magnesia in the greatest abundance.

It frequently happens that the secondary schisti are interspersed with pyrites; and, in this case, the simple contact of air and water facilitates their decomposition. Sulphuric acid is thus formed, which combines with the various constituent principles of the stone; whence result the sulphate of iron, of magnesia, of alumina, and of lime, which effloresce at the surface, and remains confounded together. Schisti of this nature are wrought in most places where alum-works have been established; and the most laborious part of this undertaking consists in separating the sulphates of iron, of lime, and of magnesia from each other, which are mixed together. Sometimes the magnesia is so abundant that its sulphate predominates. The sulphate of lime, being very sparingly soluble in water, is carried away by that liquid, and deposited to form gypsum; while the other more soluble salts, remaining suspended, form vitriolic mineral waters.

The pyritous schisti are frequently impregnated with bitumen, and the proportions constitute the various qualities of pit-coal.

It appears that we may lay it down as an incontestable principle, that the pyrites is abundant is proportion as

the bituminous principle is more scarce. Hence it arises, that coals of a bad quality are the most sulphureous, and destroy metallic vessels, by converting them into pyrites. The foci of volcanos appear to be formed by a schistus of this nature; and in the analyses of the stony matters which are ejected, we find the same principles as those which constitute this schistus. We ought not therefore to be much surprised at finding schorls among volcanic products; and still less at observing that subterranean fires throw sulphuric salts, sulphur, and other analogous products, out of the entrails of the earth.

3. The remains of terrestrial vegetables exhibit a mixture of primitive earths more or less coloured by iron: we may therefore consider these as a matrix in which the seeds of all stony combinations are dispersed. The earthy principles assort themselves according to the laws of their affinities; and form crystals of spar, of plaister, and even the rock crystals, according to all appearance: for we find ochreous earths in which these crystals are abundantly dispersed; we see them formed almost under our eyes. We have frequently observed indurated ochres full of these crystals terminating in two pyramids.

The ochreous earths appear to deserve the greatest attention of naturalists. They constitute one of the most fertile means of action which nature employs; and it is even in earths nearly similar to these that she elaborates the diamond, in the kingdoms of Golconda and Visapour.

The spoils of animals, which live on the surface of the globe, are entitled to some consideration among the number of causes which we assign to explain the various changes our planet is subjected to. We find bones in a state of considerable preservation in certain places; we can even frequently enough distinguish the species of the animals to which they have belonged. From indications of this sort it is that some writers have endeavoured to explain the disappearance of certain species; and to draw conclusions thence, either that our planet is perceptibly cooled, or that a sensible change has taken place in the position of the axis of the earth. The phosphoric salts and phosphorus which have been found, in our time, in combination with lead, iron, &c. prove that, in proportion as the principles are disengaged by animal decomposition, they combine with other bodies, and form the nitric acid, the alkalis, and in general all the numerous kinds of nitrous salts. See MINERALOGY.

GEOMETRICAL *lines*, as observed by Newton, are distinguished into classes, orders, or genera, according to the number of the dimensions of the equation that expresses the relation between the ordinates and abscisses; or, which becomes to the same thing, according to the number of points in which they may be cut by a right line.

Thus, a line of the first order, is a right line, since it can be only once cut by another right line, and is expressed by the simple equation $y + ax + b = 0$; those of the 2d, or quadratic order, will be the circle, and the conic sections, since all these may be cut in two points by a right line, and expressed by the equation $y^2 + \overline{ax + b} \,.\, y + cx^2 + dx + e = 0$; those of the 3d cubic order, will be such as may be cut in three points by a right line, whose most general equation is $y^3 + \overline{ax + b} \,.\, y^2 + \overline{cx^2 + dx + e} \,.\, y + fx^3 + gx^2 + bx + i = 0$; as the cubical parabola, the cissoid, &c. And a line of an infinite order, is that which a right line may cut in infinite points; as the spiral, the cycloid, the quadratrix, and every line that is generated by the infinite revolutions of a radius, or circle, or wheel, &c.

In each of those equations, x is the absciss, y its corresponding ordinate, making any given angle with it; and a, b, c, &c. are given or constant quantities, affected with their signs $+$ and $-$, of which one or more may vanish, be wanting or equal to nothing, provided that by such defect the line or equation does not become one of an inferior order.

It is to be observed that a curve of any kind is denominated by a number next less than the line of the same kind: thus, a curve of the first order (because the right line cannot be reckoned among curves), is the same with a line of the second order; and a curve of the second kind, the same with a line of the third order, &c.

It is to be observed also, that it is not so much the equation, as the construction or description, that makes any curve, geometrical, or not. Thus, the circle is a geometrical line, not because it may be expressed by an equation, but because its description is a postulate; and it is not the simplicity of the equation, but the easiness of the description, that is to determine the choice of the lines for the construction of a problem. The equation that expresses a parabola, is more simple than that which expresses a circle; and yet the circle, by reason of its more simple construction, is admitted before it. Again, the circle and the conic sections, with respect to the dimensions of the equations, are of the same order; and yet the circle is not numbered with them in the construction of problems, but by reason of its simple description is depressed to a lower order, viz. that of a right line; so that it is not improper to express that by a circle, which may be expressed by a right line; but it is a fault to construct that by the conic sections, which may be constructed by a circle.

GEOMETRICAL *solution* of a problem, is when the problem is directly resolved according to the strict rules and principles of geometry, and by lines that are truly geometrical. This expression is used in contradistinction to an arithmetical, or a mechanical, or instrumental solution; the problem being resolved only by a ruler and compasses.

The same term is likewise used in opposition to all indirect and inadequate kinds of solutions, as by approximation, infinite series, &c. So, we have no geometrical way of finding the quadrature of the circle, the duplicature of the cube, or two mean proportionals; though there are mechanical ways, and others by infinite series, &c.

Pappus informs us, that the ancients endeavoured in vain to trisect an angle and to find out two mean proportionals, by means of the right line and circle. Afterwards they began to consider the proprieties of several other lines; as the conchoid, the cissoid, and the conic sections; and by some of these they endeavoured to resolve some of those problems. At length, having more thoroughly examined the matter, and the conic sections being received into geometry, they distinguished geometrical problems and solutions into three kinds; viz.

1. Plane ones, which deriving their origin from lines

on a plane, may be properly resolved by a right line and a circle.

2. Solid ones, which are resolved by lines deriving their original from the consideration of a solid; that is, of a cone.

3. Linear ones, to the solution of which are required lines more compounded.

According to this distinction, we are not to resolve solid problems by other lines than the conic sections, especially if no other lines beside the right line, circle, and the conic sections, must be received into geometry.

But the moderns, advancing much farther, have received into geometry all lines that can be expressed by equations; and have distinguished, according to the dimensions of the equations, those lines into classes or orders; and have laid it down as a law, not to construct a problem by a line of a higher order, that may be constructed by one of a lower.

Geometrical progression, or proportion. See Algebra.

GEOMETRY, the science and doctrine of local extension, as of lines, surfaces, and solids, with that of ratios, &c.

The name geometry literally signifies measuring of the earth, as it was the necessity of measuring the land that first gave occasion to contemplate the principles and rules of this art, which has since been extended to numberless other speculations; insomuch that, together with arithmetic, geometry forms now the chief foundation of all the mathematics.

Herodotus and Proclus ascribe the invention of geometry to the Egyptians, and assert that the annual inundations of the Nile gave occasion to it; for those waters bearing away the bounds and landmarks of estates and farms, covering the face of the ground uniformly with mud, the people, say they, were obliged every year to distinguish and lay out their lands by the consideration of their figure and quantity; and thus by experience and habit they formed a method or art, which was the origin of geometry. A farther contemplation of the draughts of figures of fields, thus laid down and plotted in proportion, might naturally lead them to the discovery of some of their excellent and wonderful properties; which speculation continually improving, the art continually gained ground, and made advances more and more towards perfection.

Geometry is distinguished into theoretical or speculative, and practical.

Theoretical or speculative geometry, treats of the various properties and relations in magnitudes, demonstrating the theorems, &c. And

Practical geometry, is that which applies those speculations and theorems to particular uses in the solution of problems, and in the measurements in the ordinary concerns of life.

Speculative geometry again may be divided into elementary and sublime.

Elementary or common geometry, is that which is employed in the consideration of right lines and plane surfaces, with the solids generated from them. And the

Higher or sublime geometry, is that which is employed in the consideration of curve lines, conic sections, and the bodies formed of them. This part has been chiefly cultivated by the moderns, by help of the improved state of algebra, and the modern analysis or fluxions.

We shall now proceed to give the principles of practical geometry, beginning with

Definitions or explanations of terms.—1. A mathematical point has neither length, breadth, nor thickness. From this definition it may be easily understood that a mathematical point cannot be seen nor felt; it can only be imagined. What is commonly called a point, as a small dot made with a pencil or pen, or the point of a needle, is not in reality a mathematical point; for however small such a dot may be, yet if it be examined with a magnifying glass, it will be fround to be an irregular spot, of a very sensible length and breadth; and our not being able to measure its dimensions with the naked eye, arises only from its smallness. The same reasoning may be applied to every thing that is usually called a point; even the point of the finest needle appears like that of a poker when examined with the microscope.

2. A line is length without breadth or thickness. What was said above of a point, is also applicable to the definition of a line. What is drawn upon paper with a pencil or pen, is not in fact a line, but the representation of a line. For however fine you may make these representations, they will still have some breadth. But by the definition, a line has no breadth whatever, yet it is impossible to draw any thing so fine as to have no breath. A line therefore can only be imagined. The ends of a line are points.

3. Parallel lines are such as always keep at the same distance from each other, and which, if prolonged ever so far, would never meet. See Plate Geometry, fig. 1.

4. A right line is what is commonly called a straight line, or one that tends every where the same way.

5. A curve is a line which continually changes its direction between its extreme points.

6. An angle is the inclination or opening of two lines meeting in a point, fig. 2.

7. The lines AB, and BC, which form the angle, are called the legs or sides: and the point B, where they meet, is called the vertex of the angle, or the angular point. An angle is sometimes expressed by a letter placed at the vertex, as the angle B, fig. 2; but most commonly by three letters, observing to place in the middle the letter at the vertex, and the other two are those at the end of each leg, as the angle ABC.

8. When one line stands upon another, so as not to lean more to one side than to another, both the angles which it makes with the other are called right angles, as the angles ABC and ABD, fig. 3; and all right angles are equal to each other, being all equal to 90°; and the line AB is said to be perpendicular to CD.

Beginners are very apt to confound the terms perpendicular, and plumb or vertical line. A line is vertical when it is at right angles to the plane of the horizon, or level surface of the earth, or to the surface of water, which is always level. The sides of a house are vertical. But a line may be perpendicular to another, whether it stand upright, or inclines to the ground, or even if it lies flat upon it, provided only that it makes the two angles formed by meeting with the other line equal to each other; as for instance, if the angles ABC and ABD be

equal, the line AB is perpendicular to CD, whatever may be its position in other respects.

9. When one line BE (fig. 3), stands upon another, CD, so as to incline, the angle EBC, which is greater than a right angle, is called an obtuse angle; and that which is less than a right angle is called an acute angle, as the angle EBD.

10. Two angles which have one leg in common, as the angles ABC and ABE, are called contiguous angles, or adjoining angles; those which are produced by the crossing of two lines, as the angles EBD and CBF, formed by CD and EF, crossing each other, are called opposite or vertical angles.

11. A figure is a bounded space, and is either a surface or a solid.

12. A superficies, or surface, has length and breadth only. The extremities of a superficies are lines.

13. A plane, or plane surface, is that which is every where perfectly flat and even, or will touch every part of a straight line, in whatever direction it may be laid upon it. The top of a marble slab, for instance, is an example of this, which a straight edge will touch in every point, so that you cannot see light any where between.

14. A curved surface is that which will not coincide with a straight line in any part. Curved surfaces may be either convex or concave.

15. A convex surface is when the surface rises up in the middle; as, for instance, a part of the outside of a globe.

16. A concave surface is when it sinks in the middle, or is hollow, and is the contrary to convex.

A surface may be bounded either by straight lines, curved lines, or both these.

17. Every surface bounded by straight lines only is called a polygon. If the sides are all equal, it is called a regular polygon. If they are unequal, it is called an irregular polygon. Every polygon, whether equal or unequal, has the same number of sides as angles, and they are denominated sometimes according to the number of sides, and sometimes from the number of angles they contain. Thus a figure of three sides is called a triangle, and a figure of four sides a quadrangle.

A pentagon is a polygon of five sides; a hexagon has six sides; a heptagon seven sides; an octagon eight sides; a nonagon nine sides; a decagon ten sides; an undecagon eleven sides; a duodecagon twelve sides. See PENTAGON, &c.

When they have a greater number of sides it is usual to call them polygons of 13 sides, of 14 sides, and so on.

Triangles are of different kinds, according to the lengths of their sides.

18. An equilateral triangle has all its sides equal, as ABC, fig. 4.

19. An isosceles triangle has two equal sides, as DEF, fig. 5.

20. A scalene triangle has all its sides unequal, as GHI, fig. 6.

Triangles are also denominated according to the angles they contain.

21. A right angled triangle is one that has in it a right-angle, as ABC, fig. 7.

22. A triangle cannot have more than one right angle. The side opposite the right angle B, as AC, is called the hypothenuse, and is always the longest side.

23. An obtuse-angled triangle has one obtuse angle, as fig. 8.

24. An acute-angled triangle has all its angles acute, as fig. 4.

25. An isosceles, or a scalene triangle, may be either right angled, obtuse, or acute.

26. Any side of a triangle is said to subtend the angle opposite to it: thus AB (fig. 7) subtends the angle ACB.

27. If the side of a triangle be drawn out beyond the figure AD (fig. 8), the angle A, or CAB, is called an internal angle, and the angle CAD, or that without the figure, an external angle.

28. A quadrangle is also called a quadrilateral figure. They are of various denominations, as their sides are equal or unequal, or as all their angles are right-angles or not.

29. Every four-sided figure whose opposite sides are parallel, is called a parallelogram. Provided that the sides opposite to each other be parallel, it is immaterial whether the angles are right or not. Figs. 9, 10, 11, and 12, are all parallelograms.

30. When the angles of a parallelogram are all right angles, it is called a rectangular parallelogram, or a rectangle, as figs. 11 and 12.

31. A rectangle may have all its sides equal, or only the opposite sides equal. When all its sides are equal, it is called a square, as fig. 12.

32. When the opposite sides are parallel, and all the sides equal to each other, but the angles not right angles, the parallelogram is called a rhombus, as fig. 10.

33. A parallelogram having all its angles oblique, and only its opposite equal, is called a rhomboid, as fig. 9.

34. When a quadrilateral, or four-sided figure, has none of its sides parallel, it is called a trapezium, as fig. 13; consequently every quadrangle, or quadrilateral, which is not a parallelogram, is a trapezium.

35. A trapezoid has only one pair of its sides parallel, as fig. 14.

36. A diagonal is a right line drawn between any two angles that are opposite in a polygon, as IK, fig. 15. In parallelograms the diagonal is sometimes called the diameter, because it passes through the centre of the figure.

37. Complements of a parallelogram. If any point, as E (fig. 15), be taken in the diagonal of a parallelogram, and through that point two lines are drawn parallel to the sides, as AB, CD, it will be divided into four parallelograms, D, D, L, F, G, G. The two divisions, L, F, through which the diameter does not pass, are called the complements.

38. Base of a figure, is the side on which it is supposed to stand erect, as AD and CD, fig. 16.

39. Altitude of a figure is its perpendicular height from the base to the highest part, as EF, fig. 16.

40. Area of a plane figure, or other surface, means the quantity of space contained within its boundaries, expressed in square feet, yards, or any other superficial measure.

41. Similar figures are such as have the same angles, and whose sides are in the same proportion, as fig. 17.

42. Equal figures are such as have the same area or contents.

43. A circle is a plane figure, bounded by a curve line returning into itself, called its circumference, ABCD (fig. 18), every where equally distant from a point E within the circle, which is called the centre.

44. The radius of a circle is a straight line drawn from the centre to the circumference, as EF (fig. 18). The radius is the opening of the compass when a circle is described; and consequently all the radii of a circle must be equal to each other.

45. A diameter of a circle is a straight line drawn from one side of the circumference to the other through the centre, as CB (fig. 18). Every diameter divides the circle into two equal parts.

46. A segment of a circle is a part of a circle cut off by a straight line drawn across it. The straight line is called the chord. A segment may be either equal to, greater, or less than, a semicircle, which is a segment formed by the diameter of the circle, as CEB, and is equal to half the circle.

47. A tangent is a straight line drawn so as just to touch a circle without cutting it, as GH (fig. 18). The point A, where it touches the circle, is called the point of contact. And a tangent cannot touch a circle in more points than one.

48. A sector of a circle is a space comprehended between two radii and an arc, as IK, fig. 19.

49. The circumference of every circle, whether great or small, is supposed to be divided into 360 equal parts, called degrees; and every degree into 60 parts, called minutes; and every minute into 60 seconds. To measure the inclination of lines to each other, or angles, a circle is described round the angular point as a centre, as IK, fig. 19; and according to the number of degrees, minutes, and seconds, cut off by the sides of the angle, so many degrees, minutes, and seconds, it is said to contain. Degrees are marked by °, and minutes by ′, and seconds by ″; thus an angle of 48 degrees, 15 minutes, and 7 seconds, is written in this manner, 48° 15′ 7″.

50. A solid is any body that has length, breadth, and thickness: a book, for instance, is solid, so is a sheet of paper; for though its thickness is very small, yet it has some thickness. The boundaries of a solid are surfaces.

51. Similar solids are such as are bounded by an equal number of similar planes.

52. A prism is a solid, of which the sides are parallelograms, and the two ends or bases are similar polygons, parallel to each other. Prisms are denominated according to the number of angles in the base, triangular prisms, quadrangular, heptangular, and so on, as figs. 20, 21, 22, 23. If the sides are perpendicular to the plane of the base, it is called an upright prism; if they are inclined, it is called an oblique prism.

53. When the base of a prism is a parallelogram, it is called a parallelopipedon, as figs. 22 and 23. Hence a parallelopipedon is a solid terminated by six parallelograms.

54. When all the sides of a parallelopipedon are squares, the solid is called a cube, as fig. 23.

55. A rhomboid is an oblique prism, whose bases are parallelograms (fig. 24).

56. A pyramid (figs. 25 and 26) is a solid bounded by, or contained within, a number of planes, whose base may be any polygon, and whose faces are terminated in one point, B, commonly called the vertex of the pyramid.

57. When the figure of the base is a triangle, it is called a triangular pyramid; when the figure of the base is a quadrilateral, it is called a quadrilateral pyramid, &c.

58. A pyramid is either regular or irregular, according as the base is regular or irregular.

59. A pyramid is also right or upright, or it is oblique. It is right, when a line drawn from the vertex to the centre of the base, is perpendicular to it, as fig. 25; and oblique, when this line inclines, as fig. 26.

60. A cylinder is a solid (figs. 27 and 28), generated or formed by the rotation of a rectangle about one of its sides, supposed to be at rest: this quiescent side is called the axis of the cylinder. Or it may be conceived to be generated by the motion of a circle, in a direction perpendicular to its surface, and always parallel to itself.

61. A cylinder is either right or oblique, as the axis is perpendicular to the base or inclined.

62. Every section of a right cylinder taken at right angles to its axis, is a circle; and every section taken across the cylinder, but oblique to the axis, is an ellipsis.

63. A circle being a polygon of an infinite number of sides, it follows, that the cylinder may be conceived as a prism, having such a polygon for bases.

64. A cone is a solid (figs. 29 and 30), having a circle for its base, and its sides a convex surface, terminating in a point A, called the vertex, or apex of the cone. It may be conceived to be generated by the revolution of a right-angled triangle about its perpendicular.

65. A line drawn from the vertex to the centre of the base is the axis of the cone.

66. When this line is perpendicular to the base, the cone is called an upright, or right cone; but when it is inclined it is called an oblique cone.

67. If it be cut through the axis from the vertex to the base, the section will be a triangle.

68. If a right cone be cut by a plane at right angles to the axis, the section will be a circle.

69. If it be cut oblique to the axis, and quite across from one side to the other, the section will be an ellipsis, as fig. 31. A section of a cylinder made in the same manner is also an ellipsis; and that is easily conceived: but it does not appear so readily to most people, that the oblique section of a cone is an ellipsis: they frequently imagine that it will be wider at one end than the other, or what is called an oval, which is the shape of an egg. But that this is a mistake, any one may convince himself by making a cone, and cutting it across obliquely; it will be then seen that the section, in whatever direction it is taken, is a regular ellipsis; and this is the case, whether the cone be right or oblique, except only in one case in the oblique cone; which is when the section is taken in a particular direction, which is called sub-contrary to its base.

70. When the section is made parallel to one of the sides of the cone, as fig. 32, the curve ABC, which bounds the section, is called a parabola.

71. When the section is taken parallel to the axis, as fig. 33, the curve is called a hyperbola.

These curves, which are formed by cutting a cone in

different directions, have various properties, which are of great importance in astronomy, gunnery, perspective, and many other sciences.

72. A sphere is a solid, terminated by a convex surface, every point of which is at an equal distance from a point within, called the centre, fig. 34.

73. It may be conceived to be formed by making a semicircle revolve round its diameter. This may be illustrated by the process of forming a ball of clay by the potter's wheel, a semicircular mould being used for the purpose. The diameter of the semicircle round which it revolves, is called the axis of the sphere.

74. The ends of the axis are called poles.

75. Any line passing through the centre of the sphere, and terminated by the circumference, is a diameter of the sphere.

76. Every section of a sphere is a circle; every section taken through the centre of the sphere is called a great circle, as AB, fig. 34; every other is a lesser circle, as CD.

77. Any portion of a sphere cut off by a plane is called a segment; and when the plane passes through the centre, it divides the sphere into two equal parts, each of which is called a hemisphere.

78. A spheroid is a solid (fig. 35), generated by the rotation of a semi-ellipsis about the transverse or conjugate axis; and the centre of the ellipsis is the centre of the spheroid.

79. The line about which the ellipsis revolves is called the axis. If the spheroid be generated about the conjugate axis of the semi-ellipsis, it is called a prolate spheroid.

80. If the spheroid be generated by the semi-ellipsis by revolving about the transverse axis, it is called an oblong spheroid.

81. Every section of a spheroid is an ellipsis, except when it is perpendicular to that axis about which it is generated; in which case it is a circle.

82. All sections of a spheroid parallel to each other, are similar figures.

A frustum of a solid, means a piece cut off from the solid by a plane passed through it, usually parallel to the base of the solid, as the frustum of a cone, a pyramid, &c.

There are a lower and an upper frustum, according as the piece spoken of does or does not contain the base of the solid.

83. Ratio is the proportion which one magnitude bears to another of the same kind, with respect to quantity, and is usually marked thus, A : B.

Of these the first is called the antecedent, and the second the consequent.

84. The measure or quantity of a ratio is conceived by considering what part of the consequent is the antecedent; consequently it is obtained by dividing the consequent by the antecedent.

85. Three magnitudes or quantities, A, B, C, are said to be proportional, when the ratio of the first to the second is the same as that of the second to the third. Thus 2, 4, 8, are proportional; because 4 is contained in 8 as many times as 2 is in 4.

86. Four quantities, A, B, C, D, are said to be proportional when the ratio of the first A to the second B is the same as the ratio of the third C to the fourth D. It is usually written A : B : : C : D, or, if expressed in numbers, 2 : 4 : : 8 : 16.

87. Of three proportional quantities, the middle one is said to be a mean proportional between the other two; and the last a third proportional to the first and second.

88. Of four proportional quantities, the last is said to be a fourth proportional to the other three, taken in order.

89. Ratio of equality is that which equal numbers bear to each other.

90. Inverse ratio is when the antecedent is made the consequent, and the consequent the antecedent. Thus, if 1 : 2 :: 3 : 6; then inversely, 2 : 1 :: 6 : 3.

91. Alternate proportion is when antecedent is compared with antecedent, and consequent with consequent. Thus, if 2 : 1 :: 6 : 3; then by alteration 2 : 6 :: 1 : 3.

92. Proportion by composition is when the antecedent and consequent, taken as one quantity, are compared either with the consequent or with the antecedent. Thus, if 2 : 1 :: 6 : 3; then by composition 2 + 1 : 1 :: 6 + 3 : 3: and 2 + 1 : 2 : 6 + 3 : 6.

93. Divided proportion is when the difference of the antecedent and consequent is compared either with the consequent or with the antecedent. Thus, if 3 : 1 :: 12 : 4; then, by division, 3 — 1 : 1 :: 12 — 4 : 4, and 3 — 1 : 3 :: 12 — 4 : 12.

94. Continued proportion is when the first is to the second as the second is to the third; as the third to the fourth; as the fourth to the fifth; and so on.

95. Compound ratio is formed by the multiplication of several antecedents and the several consequents of ratios together, in the following manner:

If A be to B as 3 to 5, B to C as 5 to 8, and C to D as 8 to 6; then A will be D, as $\frac{3 \times 5 \times 8}{5 \times 8 \times 6} = \frac{120}{240} = \frac{1}{2}$; that is, A : D :: 1 : 2.

96. *Bisect* means to divide any thing into two equal parts.

97. *Trisect* is to divide any thing into three equal parts.

98. *Inscribe*, to draw one figure within another, so that all angles of the inner figure touch either the angles, sides, or planes, of the external figure.

99. *Circumscribe*, to draw a figure round another, so that either the angles, sides, or planes of the circumscribed figure, touch all the angles of the figure within it.

100. Rectangle under any two lines, means a rectangle which has two of its sides equal to one of the lines, and two of them equal to the other. Also the rectangle under AB, CD, means AB × CD.

101. Scales of equal parts. A scale of equal parts is only a straight line, divided into any number of equal parts at pleasure. Each part may represent any measure you please, as an inch, a foot, a yard, &c. One of these is generally subdivided into parts of the next denomination, or into tenths and hundredths. Scales may be constructed in a variety of ways. The most usual manner is to make an inch, or some aliquot part of an inch, to represent a foot; and then they are called inch scales, three-quarter-inch scales, half-inch scales, quarter-inch scales, &c. They are usually drawn upon ivory or boxwood. See Instruments.

102. An axiom is a manifest truth, not requiring any demonstration.

103. Postulates are things required to be granted true, before we proceed to demonstrate a proposition.

104. A proposition is when something is either proposed to be done, or to be demonstrated; and is either a problem or a theorem.

105. A problem is when something is proposed to be done, as some figure to be drawn.

106. A theorem is when something is proposed to be demonstrated or proved.

107. A lemma is when a premise is demonstrated, in order to render the thing in hand more easy.

108. A corollary is an inference drawn from the demonstration of some proposition.

109. A scholium is when some remark or observation is made upon something mentioned before.

110. The sign = denotes that the quantities betwixt which it stands are equal.

111. The sign + denotes that the quantity after it, is to be added to that immediately before it.

112. The sign — denotes that the quantity after it is to be taken away, or subtracted from, the quantity preceding it.

Geometrical Problems.

Prob. 1. To divide a given line AB into two equal parts.

From the points A and B as centres, and with any opening of the compasses greater than half AB, describe arches, cutting each other in c and d. Draw the line c d; and the point E, where it cuts AB, will be the middle required.

Prob. 2. To raise a perpendicular to a given line AB, from a point given at C.

Case 1. When the given point is near the middle of the line on each side of the point C. Take any two equal distances, C d and C e; from d, and e, with any radius or opening of the compasses greater than C d, or C e, describe two arcs cutting each other in f. Lastly, through the points f, C, draw the line f C, and it will be the perpendicular required.

Case 2. When the point is at, or near, the end of the line. Take any point d, above the line, and with the radius or distance d C, describe the arc e C f, cutting AB in e and C. Through the centre d, and the point e, draw the line e d f, cutting the arc e C f in f. Through the points f, C, draw the line f C, and it will be the perpendicular required.

Prob. 3. From a given point f, to let fall a perpendicular upon a given line AB.

From the point f, with any radius, describe the arc d e, cutting AB in e and d. From the points e d, with the same or any other radius, describe the two arcs, cutting each other in g. Through the points f and g, draw the line f g, and f C will be the perpendicular required.

Prob. 4. To make an angle equal to another angle which is given, as a B b.

From the point B, with any radius, describe the arc a b, cutting the legs B a, B b, in the points a and b. Draw the line D e, and from the point D, with the same radius as before, describe the arc e f, cutting D e in e. Take the distance b a, and apply it to the arc e f, from e to f. Lastly, through the points D, f, draw the line D f, and the angle e D f will be equal to the angle b B a, as was required.

Prob. 5. To divide a given angle, ABC, into two equal angles.

From the point B, with any radius, describe the arc AC. From A and C with the same, or any other radius, describe arcs cutting each in d. Draw the line B d, and it will bisect the angle ABC, as was required.

Prob. 6. To lay down an angle of any number of degrees.

There are various methods of doing this. One is by the use of an instrument called a protractor, with a semicircle of brass, having its circumference divided into degrees. Let AB be a given line, and let it be required to draw from the angular point A, a line making with AB any number of degrees, suppose 20. Lay the straight side of the protractor along the line AB, and count 20° from the end B of the semicircle; at C, which is 20° from B, mark; then, removing the protractor, draw the line AC, which makes with AB the angle required. Or, it may be done by a divided line, usually drawn upon scales, called a line of chords. Take 60° from the line of chords in the compasses, and setting one at the angular point B, prob. 4, with that opening as a radius, describe an arch, as a b: then take the number of degrees you intend the angle to be of, and set it from b to a, then is a B b the angle required. See Instruments.

Prob. 7. Through a given point C, to draw a line parallel to a given line AB.

Case 1. Take any point d, in AB; upon d and C, with the distance C d, describe two arcs, e C, and d f, cutting the line AB in e and d. Make d f equal to e C; through C and f draw C f, and it will be the line required.

Case 2. When the parallel is to be at a given distance from AB. From any two points, c and d, in the line AB, with a radius equal to the given distance, describe the arcs e and f: draw the line CB to touch those arcs without cutting them, and it will be parallel to AB, as was required.

Prob. 8. To divide a given line AB, into any proposed number of equal parts.

From A, one end of the line, draw A c, making any angle with AB; and from B, the other end, draw B d, making the angle ABd equal to BAc. In each of these lines, A c, B d, beginning at A and B, set off as many equal parts of any length as AB is to be divided into. Join the points C 5, 46, 57, and AB will be divided as required.

Prob. 9. To find the centre of a given circle, or of any one already described. Draw any chord, AB, and bisect it with the perpendicular CD. Bisect CD with the diameter EF, and the intersection O will be the centre required.

Prob. 10. To draw a tangent to a given circle that shall pass through a given point, A.

From the centre O, draw the radius OA. Through the point A, draw DE perpendicular to OA, and it will be the tangent required.

Prob. 11. To draw a tangent to a circle, or any segment of a circle ABC, through a given point B, without making use of the centre of the circle.

Take any two equal divisions upon the circle from the

given point B, towards d and e, and draw the chord e B. Upon B, as a centre, with the distance B d, describe the arc f d g. cutting the chord e B in f. Make d g equal to d f; through g draw g B, and it will be the tangent required.

Prob. 12. Given three points, A, B, C, not in a straight line, to describe a circle that shall pass through them.

Bisect the lines AB, BC, by the perpendiculars a d, b d, meeting at d. Upon d, with the distance d A, d B, describe ABC, and it will be the required circle.

Prob. 13. To describe the segment of a circle to any length AB, and height CD.

Bisect AB by the perpendicular D g, cutting AB in c. From c make c D on the perpendicular equal to CD. Draw AD, and bisect it by a perpendicular e f, cutting D g in g. Upon g the centre, describe ADB, and it will be the required segment.

Prob. 14. In any given triangle to inscribe a circle.

Bisect any two angles, A and C, with the lines AD and DC. From D the point of intersection, let fall the perpendicular DE; it will be the radius of the circle required.

Prob. 15. In a given square, to describe a regular octagon.

Draw the diagonals AC and BD, intersecting at e. Upon the points A, B, C, D, as centres, with a radius e C, describe the arcs k e n, m e g, f e i, &c. Join f n, m b, k i, l g, and it will be the required octagon.

Prob. 16. In a given circle, to describe any regular polygon.

Divide the circumference into as many parts as there are sides in the polygon to be drawn, and join the points of division.

Prob. 17. Upon a given line AB, to construct an equilateral triangle.

Upon the points A, and B, with a radius equal to AB, describe arches cutting each other at C. Draw AC and BC, and ABC will be the triangle required.

Prob. 18. To make a trapezium equal and similar to a given trapezium ABCD.

Divide the given trapezium ABCD into two triangles by the diagonal DB. Make EF equal to AB; upon EF construct the triangle EFH, whose sides shall be respectively equal to those of the triangle ABD by the last problem. Upon HF, which is equal to DB, construct the triangle HFG, whose sides are respectively equal to DBC; then EFGH will be the trapezium required.

By the help of this problem any plan may be copied; as every figure, how ever irregular, may be divided into triangles. Upon this the practice of land-surveying and making plans of estates, is founded.

Prob. 19. To make a square equal to two given squares. Make the sides DE and DF of the two given squares A and B, form the sides of a right-angled triangle FDE; draw the hypothenuse FE; on it describe the square EFGH, and it will be the square required.

Prob. 20. Between two given lines, AB and CD, to find a mean proportional.

Draw the right line EG, in which make EF equal to AB, and FG equal to CD. Bisect EG in H, and with HE or HG, as radius, describe the semicircle EIG. From F draw FI perpendicular to EG, cutting the circle in I; and IF will be the mean proportional required.

GEOMETRY, *application of algebra to.* When a geometrical problem is proposed to be resolved by algebra, you are, in the first place, to describe a figure that shall represent, or exhibit, the several parts or conditions thereof, and look upon that figure as the true one; then, having considered attentively the nature of the problem you are next to prepare the figure for a solution (if need be), by producing and drawing such lines therein as appear most conducive to that end. This done, let the unknown line or lines which you think will be the easiest found (whether required or not), together with the known ones (or as many of them as are requisite), be denoted by proper symbols; then proceed to the operation, by observing the relation that the several parts of the figure have to each other; in order to which a competent knowledge of the elements of geometry is absolutely necessary.

As no general rule can be given for the drawing of lines, and electing the most proper quantities to substitute for, so as to always bring out the most simple conclusions (because different problems require different methods of solution); the best way, therefore, to gain experience in this matter, is to attempt the solution of the same problem several ways, and then apply that which succeeds best to other cases of the same kind when they afterwards occur. We shall, however, subjoin a few general directions, which will be found of use.

1. In preparing the figure, by drawing lines, let them be either parallel or perpendicular to other lines in the figure, or so as to form similar triangles; and, if an angle be given, let the perpendicular be opposite to that angle, and also fall from the end of a given line, if possible.

2. In electing the proper quantities to substitute for, let those be chosen (whether required or not) which lie nearest the known, or given parts of the figure, and by help whereof the next adjacent parts may be expressed, without the intervention of surds, by addition and subtraction only. Thus, if the problem were to find the perpendicular of a plane triangle, from the three sides given, it will be much better to substitute for one of the segments of the base than for the perpendicular, though the quantity required; because the whole base being given, or expressed, by subtraction only, and so the final equation comes out a single one; from whence the segments being known, the perpendicular is easily found by common arithmetic: whereas, if the perpendicular were to be first sought, both the segments would be surd quantities, and the final equation an unsightly quadratic one.

3. When, in any problem, there are two lines or quantities alike related to other parts of the figure, or problem, the best way is to make use of neither of them, but to substitute for their sum, their rectangle, or the sum of their alternate quotients, or for some line or lines in the figure, to which they have both the same relation.

4. If the area, or the perimeter, of a figure be given, or such parts thereof as have but a remote relation to the parts required, it will sometimes be of use to assume another figure similar to the proposed one, whereof one side is unity, or some other known quantity; from whence the other parts of this figure, by the known proportions of the homologous sides, or parts, may be found, and an equation obtained.

These are the most general observations, which we shall now proceed to illustrate by examples.

Prob. I. *The base* (b), *and the sum of the hypothenuse and perpendicular* (a) *of a right-angled triangle* ABC, *being given; to find the perpendicular.* See Fig. 36.

Let the perpendicular BC be denoted by x; then the hypothenuse AC will be expressed by $a - x$; but (by Euc. 47. 1.) $AB^2 + BC^2 = AC$; that is, $b^2 + x^2 = a^2 - 2ax + xx$; whence $x = \frac{a^2 - b^2}{2a} =$ the perpendicular required.

Prob. II. *The diagonal, and the perimeter of a rectangle,* ABCD, *being given; to find the sides.* See Fig. 37.

Put the diagonal $BD = a$, half the perimeter $(DA + AB) = b$, and $AB = x$; then will $AD = b - x$; and therefore, $AB^2 + AD^2$ being $= BD^2$, we have $x^2 + b^2 - 2bx + x^2 = b^2$; which, solved, gives $x = \frac{\sqrt{2a^2 - b^2} + b}{2}$.

Prob. III. *The area of a right-angled triangle* ABC, *and the sides of a rectangle* EBDF, *inscribed therein, being given; to determine the sides of the triangle.* See Fig. 38.

Put $DF = a$, $DE = b$, $BC = x$, and the measure of the given area $ABC = d$; then, by similar triangles, we shall have $x - b$ (CF) : a (DF) : : x (BC) : $AB = \frac{ax}{x-b}$. Therefore $\frac{ax}{a-b} \times \frac{x}{2} = d$, and consequently $ax^2 = 2dx - 2bd$, or $x^2 - \frac{2dx}{a} = -\frac{2bd}{a}$; which, solved, gives $x = \frac{d}{a} \pm \sqrt{\frac{dd}{aa} - \frac{2bd}{a}}$; from whence AB and AC will likewise be known.

Prob. IV. *Having the lengths of the three perpendiculars,* PF, PG, PH, *drawn from a certain point* P, *within an equilateral triangle* ABC, *to the three sides thereof; from thence to determine the sides.* See Fig. 39.

Let lines be drawn from P to the three angles of the triangle; and let CD be perpendicular to AB: call PF, a; PG, b; PH, c; and $AD = x$: then will AC $(= AB) = 2x$, and $CD (= \sqrt{AC^2 - AD^2}) = \sqrt{3xx} = x\sqrt{3}$; and consequently the area of the whole triangle ABC $(= CD \times AD) = xx\sqrt{3}$. But this triangle is composed of the three triangles APB, BPC, and APC; whereof the respective areas are ax, bx, and cx. Therefore we have $xx\sqrt{3} = ax + bx + cx$; and from thence, by division, $x = \frac{a+b+c}{\sqrt{3}}$.

Prob. V. *Having the area of a rectangle* DEFG, *inscribed in a given triangle* ABC; *to determine the sides of the rectangle.* See Fig. 40.

Let CI be perpendicular to AB, cutting DG in H; and let $CI = a$, $AB = b$, $DG = x$, and the given area $= cc$; then it will be, as $b : x : : a : \frac{ax}{b} = CH$; which, taken from CI, leaves $a - \frac{ax}{b} = IH$; and this, multiplied by x, gives $ax - \frac{ax^2}{b} = cc =$ the area of the rectangle; whence we have $abx - ax^2 = bcc$, $x^2 - bx = -\frac{bcc}{a}$, $x - \frac{b}{2} = \pm\sqrt{\frac{b^2}{4} - \frac{bcc}{a}}$, and $x = \frac{b}{2} \pm \sqrt{\frac{b^2}{4} - \frac{bcc}{a}}$.

Prob. VI. *Through a given point* P, *within a given circle, so to draw a right line, that the two parts thereof,* PR, PQ, *intercepted by that point and the circumference of the circle, may have a given difference.* See Fig. 41.

Let the diameter PBA be drawn; and let AP and BP, the two parts thereof (which are supposed given) be denoted by a and b; making $PR = x$, and $PQ = x + d$ (d being the given difference). Then, by the nature of the circle, $PQ \times PR$ being $= PA \times PB$, we have $\overline{x + d} \times x = ab$, or $xx + dx = ab$; whence x is found $= \sqrt{ab + \frac{1}{4}dd} - \frac{1}{2}d$.

Prob. VII. *From a given point* P, *without a given circle, so to draw a right line* PQ, *that the part thereof* RQ, *intercepted by the circle, shall be to the external part* PR, *in a given ratio.* See Fig. 42.

Through the centre O, draw PAB; put $PA = a$, $PB = b$, $PR = x$, and let the given ratio of PR to RQ be that of m to n; then it will be, as $m : n : : x : n\frac{nx}{m} = RQ$; therefore $PQ = x + \frac{nx}{m}$: but $PR \times PQ = PA \times PB$, or $x \times \overline{x + \frac{nx}{m}} = ab$; therefore $mx^2 + nx^2 = mab$, and $x = \sqrt{\frac{b}{m+n}}$.

Prob. VIII. *The sum of the two sides of an isosceles triangle* ABC, *being equal to the sum of the base and perpendicular, and the area of the triangle being given; to determine the sides.* See Fig. 43.

Put the semi-base $AD = x$, the perpendicular $CD = y$, and the given area $ABC = a^2$; so shall $xy = a^2$, and $2\sqrt{xx + yy} = 2x + y$ (by El. 47. 1. and the conditions of the problem). Now, squaring both sides of the last equation, we have $4xx + 4yy = 4xx + 4xy + yy$; whence $3yy = 4xy$, and consequently $y = \frac{4x}{3}$; which value, substituted in the former equation, gives $\frac{4xx}{3} = a^2$; from whence $x = \sqrt{\frac{3a^2}{4}} = \frac{1}{2}a\sqrt{3}$; $y \left(= \frac{4x}{3}\right) = \frac{2}{3}a\sqrt{3}$; and AC $(= \sqrt{xx + yy} = \sqrt{\frac{3aa}{4} + \frac{4aa}{3}} = \sqrt{\frac{2\ aa}{12}}) = \frac{5}{2}a\sqrt{\frac{1}{3}} = \frac{5}{6}a\sqrt{3}$.

Prob. IX. *The segments of the base* AD *and* BD, *and the ratio of the sides* AC *and* BC *of any plane triangle* ABC, *being given; to find the sides.* See Fig. 44.

Put $AD = a$, $BD = b$, $AC = x$; and let the given ratio of AC to BC, be as m to n, so shall $BC = \frac{nx}{m}$. But $AC^2 - AD^2 (= DC^2) = BC^2 - BD^2$, that is, in species, $x^2 - a^2 = \frac{nnxx}{mm} - b^2$. Hence we have $m^2x^2 - n^2x^2 = m^2 \times aa - bb$, and $x = m\sqrt{\frac{aa - bb}{mm - nn}}$.

Geometry, *usefulness of*. The usefulness of this science extends to almost every art and science. It is by the help of it that astronomers turn their observations to advantage, regulate the duration of times, seasons, years, cycles, and epochs; and measure the distance, motions, and magnitudes, of the heavenly bodies It is by it that geographers determine the figure and magnitude of the whole earth, and delineate the extent and bearings of kingdoms. provinces, harbours, &c. It is from this science too that architects derive their just measures, in the construction of public edifices as well as of private houses. It is by the assistance of geometry that engineers conduct all their works, take the situation and plans of towns, the distances of places, and the measure of such things as are only accessible to the sight. It is not only an introduction to fortification, but highly necessary to most mechanics, especially carpenters, joiners, mathematical-instrument makers, and all who profess designing. On geometry likewise depends the theory of music, optics, perspective, drawing, mechanics, hydraulics, pneumatics, &c.

GEORGE, or *knights of St. George*. See Garter.

Religious of the order of St. George, form several congregations in Italy and other places.

GEORGIC, a poetical composition upon the subject of husbandry. See Poetry.

GERANIUM, *crane's-bill*, a genus of the decandria order, in the monadelphia class of plants, and in the natural method ranking under the 14th order, gruinales. Its characters are these: the flower has a permanent empalement, composed of five small oval leaves, and five oval or heart-shaped petals, spreading open, which are in some species equal, and in others the upper two are much larger than the three lower. It has ten stamina, alternately longer than each other, but shorter than the petals, and terminated by oblong summits. In the bottom of the flower is situated a five-cornered germen, which is permanent. The flower is succeeded by five seeds, each being wrapped up in the husk of the beak, where they are twisted together at the point, so as to form the resemblance of a stork's beak. There are 32 species.

The common wild sorts of this plant, and those also which are brought to the curious from the colder climates, are hardy enough, and require little care; but the southern species require care in their culture and propagation, and in general the protection of a greenhouse in the winter. The erodium, and the pelargorium, or African geranium, are vulgarly called by the name of geraniums, and indeed resemble this genus in every thing but the number of the stamina. The eradium has five stamina, and the pelargoriam seven.

GERARDIA, in botany, a genus of the didynamia angiospermia class of plants, the corolla of which consists of a single ringent petal; the tube is roundish, and longer than the cup; the upper lip is erect, obtuse, plain, and emarginated; the lower lip is reflected, and divided into three segments: the fruit is an oval capsule, containing two cells, and consisting of two valves; the seeds are oval and single. There are ten species, herbaceous plants of America and the Cape. One species is much recommended in gouty disorders.

GERMEN. See Botany.

GERMINATION, in botany. Natural historians have proved, by a very complete induction of facts, that all plants arise from seeds. The pretended exceptions have disappeared, one after another, as our knowledge of vegetables increased; and now there remains scarcely a single objection entitled to the smallest regard. The late attempt of Girtanner to revive the doctrine of equivocal generation deserves no attention whatever; because his conclusions are absolutely incompatible with the experiments of Mr. Sennebier upon the very substance on which his theory is founded.

A seed consists of three parts, namely, the cotyledons, the radicle, and the plumula, which are usually inclosed in a cover.

If we take a garden-bean, we may perceive each of these three parts with great ease; for this seed is of so large a size, that all its organs are exceedingly distinct. When we strip off the external coats of the bean, which are two, and of different degrees of thickness in different parts, we find that it easily divides into two lobes, pretty nearly of the same size and figure. Each of these lobes is called a cotyledon. The cotyledons of the bean, then, are two in number.

Near that part of the lobes which is contiguous to what is called the eye of the bean, there is a small round white body, which comes out between the two lobes. This body is called the radicle.

Attached to the radicle there is another small round body, which lies between the cotyledons, and wholly within them; so that it cannot be seen till they are separated from each other. The body is called the plumula.

The appearance and shape of these three parts differ very much in different seeds, but there is no seed which wants them. The figure and size of the seed depend chiefly upon the cotyledons. This is evidently the case with the bean, and it is so with all other seeds. The number of cotyledons is different in different seeds. Some seeds have only one cotyledon, as the seeds of wheat, oats, barley, and the whole tribe of grasses; some have three; others six, as the seeds of the garden-cress; but most seeds, like the bean, have two cotyledons.

When a seed is placed in a situation favourable to vegetation, it very soon changes its appearance. The radicle is converted into a root, and sinks into the earth; the plumula, on the other band, rises above the earth, and becomes the trunk or stem. When these changes take place the seed is said to germinate: the process itself has been called germination. Seeds do not germinate equally and indifferently in all places and seasons. Germination, therefore, is a process which does not depend upon the seed alone: something external must also effect it.

It is a well-kown fact, that seeds will not germinate without moisture; for seeds, if they are kept perfectly dry, never vegetate at all, and yet their power of vegetating is not destroyed. Water, then, is essential to germination. Too much water, however, is no less prejudicial to most seeds than none at all. The seeds of water-plants, indeed, germinate and vegetate extremely well in water; but most other seeds, if they are kept in water beyond a certain time, are rotted and destroyed altogether.

It is well known also, that seeds will not germinate,

even though supplied with water, provided the temperature is below a certain degree. No seed, for instance, on which the experiment has been tried, can be made to vegetate at or below the freezing-point: yet this degree of cold does not injure the vegetating power of seeds; for any seeds will vegetate as well as ever after having been frozen, or after having been kept in frozen water. We may conclude, then, that a certain degree of heat is necessary for the germination of seeds. And every species of plant seems to have a degree peculiar to itself, at which its seeds begin to germinate; for every seed has a peculiar season at which it begins to germinate, and this season varies with the temperature of the air. Mr. Adanson found that seeds, when sown at the same time in France and in Senegal, always appeared sooner above ground in the latter country, where the climate is hotter, than in France.

Seeds, although supplied with moisture, and placed in a proper temperature, will not germinate, if atmospherical air is completely excluded from them. Mr. Ray found that grains of lettuce did not germinate in the vacuum of an air-pump, but they began to grow as soon as air was admitted to them. Homberg made a number of experiments on the same subject, which were published in the Memoirs of the French Academy for the year 1693. He found that the greater number of seeds which he tried refused to vegetate in the vacuum of an air-pump. Some, however, did germinate; but Boyle, Muschenbroek, and Boerhaave, who made experiments on the same subject in succession, proved beyond a doubt that no plant vegetates in the vacuum of an air-pump; and that in those cases in which Homberg's seeds germinated, the vacuum was far from perfect, a quantity of air still remaining in the receiver. It follows, therefore, that no seed will germinate unless atmospherical air, or some air having the same properties, has access to it. It is for this reason that seeds will not germinate at a certain depth below the surface of the earth.

Mr. Scheele found that beans would not germinate except oxygen gas was present. Mr. Achard afterwards proved that oxygen gas is absolutely necessary for the germination of all seeds, and that no seed will germinate in azotic gas, or hydrogen gas, or carbonic acid gas, unless these gasses contain a mixture of oxygen gas. These experiments have been confirmed by Mr. Gough, Mr. Cruckshank, and many other philosophers. It follows, therefore, that it is not the whole atmospheric air, but merely the oxygen gas which it contains, that is necessary for the germination of seeds.

Nay, M. Humboldt has ascertained that seeds vegetate more rapidly when steeped in oxymuriatic acid, or when watered with it; and this acid is well known for the facility with which it parts with oxygen. This acid seems even to augment the vegetative power of seeds. At Vienna several seeds which had been long kept, and which had constantly refused to germinate, grew readily when treated with this acid.

Light also has considerable influence in the germination of seeds. Ingenhousz found that seeds always germinate faster in the dark than when exposed to the light. His experiments were repeated by Mr. Sennebier with equal success. But the abbe' Bertholin, who distinguished himself so much by his labours to demonstrate the effect of electricity on vegetation, objected to the conclusions of these philosophers; and affirmed that the difference in the germination of seeds in the shade and in the light was owing, not to the light itself, but to the difference of the moisture in the two situations; the moisture evaporating much faster from the seeds in the light than from those in the shade; and he affirmed, that when precautions were taken to keep the seeds equally moist, those in the sun germinated sooner than those in the shade. But when Mr. Sennebier repeated his former experiments, and employed every possible precaution to ensure the equality of moisture in both situations, he constantly found the seeds in the shade germinate sooner than those in the light. We may conclude, therefore, that light is injurious to germination; and hence one reason for covering seeds with the soil in which they are to grow.

Thus we have seen that seeds will not germinate unless moisture, heat, and oxygen gas, are present; and that they do not germinate well if they are exposed to the action of light. Now, in what manner do these substances affect the seed? What are the changes which they produce?

It was observed before, that all seeds have one or more cotyledons. These cotyledons contain a quantity of farinaceous matter, laid up on purpose to supply the embryo plant with food as it begins to require it. This food, however, must undergo some previous preparation before it can be applied by the plant to the formation or completion of its organs. Now all the phenomena of germination, which we can perceive, consists in the chemical changes which are produced in that food, and the consequent developement of the organs of the plant.

When a seed is placed in favourable circumstances, it gradually imbibes moisture, and very soon after emits a quantity of carbonic acid gas, even though no oxygen gas should be present. If no oxygen gas is present, the process stops here, and no germination takes place. But if oxygen gas is present, it is gradually absorbed by the seed; and at the same time the farina of the cotyledons assume a sweet taste, resembling sugar: it is therefore converted into sugar, or some substance analogous to it. M. Saussure, jun. has ascertained that the quantity of oxygen gas absorbed during the germination is always proportional to the carbonic acid gas emitted; that is, the carbonic acid emitted contains in it precisely the same quantity of oxygen as has been absorbed. Hence it is evident that the farina is changed into sugar by diminishing its carbon, and of course by augmenting the proportion of its hydrogen and oxygen. This is precisely the process of malting, or of converting grain into malt; during which it is well known that there is a considerable heat envolved; so much indeed, that in certain circumstances grain improperly kept has even taken fire. We may conclude from this, that during the germination of seeds in the earth there is also an evolution of a considerable portion of heat. This indeed might have been expected, as it usually happens when oxygen gas is absorbed.

So far seems to be the work of chemistry alone, at least we have no right to conclude that any other agent interferes; since hay, when it happens to imbibe moisture, exhibits nearly the same process. Carbonic acid gas is evolved, oxygen gas is absorbed, heat is produced so

abundantly that hay often takes fire: at the same time a quantity of sugar is formed. It is owing to a partial change of the same kind that old hay generally tastes much sweeter than new hay. Now we have no reason to suppose that any agents peculiar to the vegetable kingdom reside in hay: as all vegetation, and all power of vegetating, are evidently destroyed.

But when the farina in the seeds of vegetables is converted into sugar, a number of vessels make their appearance in the cotyledon. These vessels may indeed be detected in many seeds before germination commences; but they become much more distinct after it has made some progress. Branches from them have been demonstrated by Grew, Malpighi, and Hedwig, passing into the radicle, and distributed through every part of it. These evidently carry the nourishment prepared in the cotyledons to the radicle; for if the cotyledons are cut off, even after the processes above described are completed, germination, as Bonnet and Sennebier ascertained by experiment, immediately stops. The food therefore is conveyed from the cotyledons into the radicle; the radicle increases in size, assumes the form of a root, sinks down into the earth, and soon becomes capable of extracting the nourishment necessary for the future growth of the plant. Even at this period, after the radicle has become a perfect root, the plant, as Sennebier ascertained by experiment, ceases to vegetate if the cotyledons are cut off. They are still then absolutely necessary for the vegetation of the plant.

The cotyledons now assume the appearance of leaves, and appear above the ground, forming what are called the seminal leaves of the plant. After this the plumula gradually increases in size, rises out of the earth, and expands itself into branches and leaves. The seminal leaves, soon after this, decay and drop off; and the plant carries on all the processes of vegetation without their assistance.

Mr. Eller attempted to show that there is a vessel in seeds which passes from the cotyledons to the plumula; but later anatomists have not been able to perceive any such vessel. Even Mr. Hedwig, one of the most patient, acute, and successful philosophers that ever examined the structure of vegetables, could never discover any such vessel, although he traced the vessels of the cotyledons even through the radicle. As it does not appear, then, that there is any communication between the cotyledons and the plumula, it must follow that the nourishment passes into the plumula from the radicle: and accordingly we see that the plumula does not begin to vegetate till the radicle has made some progress. Since the plant ceases to vegetate, even after the radicle has been converted into a root, if the cotyledons are removed before the plumula is developed, it follows that the radicle is insufficient of itself to carry on the processes of vegetation, and that the cotyledons still continue to perform a part. Now we have seen already what that part is; they prepare food for the nourishment of the plant. The root, then, is of itself insufficient for this purpose. When the cotyledons assume the form of seminal leaves, it is evident that the nourishment, which was originally laid up in them for the support of the embryo plant, is exhausted, yet they still continue as necessary as ever. They must therefore receive the nourishment which is imbibed by the root; they must produce some changes on it, render it suitable for the purposes of vegetation, and then send it back again to be transmitted to the plumula.

After the plumula has acquired a certain size, which must be at least a line, if the cotyledons are cut off, the plant, as Mr. Bonnet ascertained by a number of experiments, afterwards repeated with equal success by Mr. Sennebier, does not cease to vegetate, but it continues always a mere pigmy: its size, when compared with that of a plant whose cotyledons are allowed to remain, being only as 2 to 7.

When the plumula has expanded completely into leaves, the cotyledons may be removed without injuring the plant, and they very soon decay of themselves. It appears, then, that this new office of the cotyledons is afterwards performed by that part of the plant which is above ground.

Thus we have traced the phenomena of germination as far as they have been detected. The facts are obvious; but the manner in which they are produced is a profound secret. We can neither explain how the food enters into the vessels, how it is conveyed to the different parts of the plant, how it is deposited in every organ, nor how it is employed to increase the size of the old parts, or to form new ones. These phenomena are analogous to nothing in mechanics or chemistry, but resemble exactly the organization and nourishment of animals. They belong therefore to that difficult branch of science known by the name of physiology.

GERUND, in grammar, a verbal noun of the neuter gender, partaking of the nature of a participle, declinable only in the singular number, through all the cases except the vocative: as, nom. *amandum*, gen. *amandi*, dat. *amando*, accus. *amandum*, abl. *amando*.

GEROPOGON, a genus of the syngenesia polygamia æqualis class and order. The calyx is simple; recept. with bristle-shaped chaffs; seeds of the disk with feathered down, of the ray with five awns. There are three species, all plants of Italy, having the same habit with the tragopogons.

GESNERIA, a genus of the angiospermia order, in the natural method ranking under the 40th order, personatæ. The calyx is quinquefid, and placed on the germen; the corolla incurved and then recurvated: the capsule inferior and bilocular. There are 12 species, herbs and shrubs of the West Indies.

GETHYLLIS, a genus of the monogynia order, in the dodecandria class of plants, and in the natural method ranking under the 9th order, spathaceæ. The corolla is six cleft, and the stamina are in six different directions; the capsule is trilocular. There are four species, herbs of the Cape.

GEUM, *avens*, or *herb-bennet*, a genus of the polygamia order, in the icosandria class of plants, and in the natural method ranking under the 35th order, senticosæ. The calyx is cleft into ten parts; there are five petals, and each of the seeds has a jointed awn. There are nine species; of which the most remarkable are,

1. The urbanum, with thick fibrous roots, of an aromatic taste: rough, serrated leaves; and upright, round, hairy stalks, terminated by large yellow flowers, succeeded by globular fruit.

2. The rivale, with a very thick, fleshy, and fibrous

root, hairy leaves, and upright stalks 10 or 12 inches high, terminated by purple flowers nodding on one side. Of this there are varieties with red and with yellow flowers. Both of these are natives of Britain, and are easily propagated either by the root or seed. The roots of the first, gathered in the spring before the stems come up, and infused in ale, give it a pleasant flavour, and prevent its growing sour: infused in wine they have a stomachic virtue. The taste is mildly austere and aromatic, especially when the plant grows in warm dry situations; but in moist shady places it has little virtue. Cows, goats, sheep, and swine, eat the plant; horses are not fond of it. The powdered root of the second species will cure tertian agues, and is daily used for that purpose by the Canadians. Sheep and goats eat the plant; cows, horses, and swine, are not fond of it.

GHINIA, a genus of the diandria monogynia class and order. The calyx is five-toothed and acuminate; cor. two-lipped; stam. four, with two barren anthers at the shorter filaments; per. a drupe, containing a four or five-celled nut, with a seed in each cell. There are two species, annuals of the West Indies.

GIANT'S-CAUSEWAY, a vast collection of basaltic pillars in the county of Antrim in Ireland. (See BASALTES.) The principal or grand causeway (for there are several less considerable and scattered fragments) consists of a most irregular arrangement of many hundred thousands of columns: almost all of them are of a pentagonal figure, but so closely and compactly situated on their sides, though perfectly distinct from top to bottom, that scarcely any thing can be introduced between them. The columns are of an unequal height and breadth; some of the highest, visible above the surface of the strand, and at the foot of the impending angular precipice, perhaps about 20 feet, they do not exceed this height, at least none of the principal arrangement. How deep they are fixed in the strand was never yet discovered. This grand arrangement extends nearly 200 yards, visible at low water; how far beyond is uncertain: from its declining appearance, however, at low water, it is probable it does not extend under water to a distance any thing equal to what is seen above. The breadth of the principal causeway which runs out in one continued range of columns, is, in general, from 20 to 30 feet; at one place or two it may be nearly 40 for a few yards. In this account are excluded the broken and scattered pieces of the same kind of construction, that are detached from the sides of the grand causeway, as they do not appear to have ever been contiguous to the principal arrangement, though they have frequently been taken into the width; which has been the cause of such wild and disimilar representations of this causeway, which different accounts have exhibited. The highest part of this causeway is the narrowest, at the very spot of the impending cliff whence the whole projects, where, for four or five yards, it is not above ten or fifteen wide. The columns of this narrow part incline from a perpendicular a little to the westward, and form a slope on their tops, by the unequal height of the columns on the two sides; by which an ascent is made at the foot of the cliff, from the head of one column to the next above, gradatim, to the top of the great causeway, which, at the distance of half a dozen yards from the cliff, obtains a perpendicular position, and, lowering in its general height, widens to about 20 or between 20 and 30 feet, and for 100 yards nearly is always above water. The tops of the columns for this length being nearly of an equal height, they form a grand and singular parade that may be easily walked on, rather inclining to the water's edge. But from high-water mark, as it is perpetually washed by the beating surges on every return of the tide, the platform lowers considerably, and becomes more and more uneven, so as not to be walked on but with the greatest care. At the distance of 150 yards from the cliff it turns a little to the east for 20 or 30 yards, and then sinks into the sea. The figure of these columns is almost unexceptionably pentagonal, or composed of five sides; there are but very few of any other figure introduced: some few there are of three, four, and six sides, but the generality of them are five sided, and the spectator must look very nicely to find any of a different construction: yet what is very extraordinary, and particularly curious, there are not two columns in ten thousand to be found, that either have their sides equal among themselves, or whose figures are alike. Nor is the composition of these columns or pillars less deserving the attention of the curious spectator. They are not of one solid stone in an upright position, but composed of several short lengths, curiously joined, not with flat surfaces, but articulated into each other like a ball and socket, or like the joints in the vertebræ of some of the larger kind of fish, the one end at the joint having a cavity into which the convex end of the opposite is exactly fitted. This is not visible but by disjoining the two stones. The depth of the concavity or convexity is generally about two or three inches. And what is still farther remarkable of the joint, the convexity, and the correspondent concavity, are not conformed to the external angular figure of the column, but exactly round, and as large as the size or diameter of the column will admit; and consequently as the angles of these columns are in general extremely unequal, the circular edges of the joint are seldom coincident with more than two or three sides of the pentagonal, and from the edge of the circular part of the joint to the exterior sides and angles they are quite plain. It is still farther very remarkable likewise, that the articulations of these joints are frequently inverted; in some the concavity is upwards, in others the reverse. This occasions that variety and mixture of concavities and convexities on the tops of the columns, which is observable throughout the platform of this causeway, yet without any discoverable design or regularity with respect to the number of either. The length also of these particular stones, from joint to joint, is various: in general they are from 18 to 24 inches long; and, for the most part, longer towards the bottom of the columns than nearer the top, and the articulation of the joints something deeper. The size or diameter likewise of the columns is as different as their length and figure: in general they are from 15 to 20 inches diameter. There are no traces of uniformity or design discovered throughout the whole combination, except in the form of the joint, which is invariably by an articulation of the convex into the concave of the piece next above or below it; nor are there any traces of a finishing in any part, either in height, length, or breadth, of this curious causeway. If there is here and there a smooth top to any of the columns

above water, there are others just by, of equal height, that are more or less convex or concave, which show them to have been joined to pieces that have been washed, or by other means taken off. And undoubtedly those parts that are always above water have, from time to time, been made as even as might be; and the remaining surfaces of the joints must naturally have been worn smoother by the constant friction of weather and walking, than where the sea, at every tide, is beating upon it, and continually removing some of the upper stones, and exposing fresh joints. And farther, as these columns preserve their diameters from top to bottom, in all the exterior ones, which have two or three sides exposed to view, the same may with reason be inferred of the interior columns whose tops only are visible. Yet, what is very extraordinary and equally curious in this phenomenon is, that notwithstanding the universal dissimilitude of the columns, both as to their figure and diameter, and though perfectly distinct from top to bottom, yet is the whole arrangement so closely combined at all points, that hardly a knife can be introduced between them either upon the sides or angles. And it is a most curious entertainment to examine the close contexture and nice insertion of such an infinite variety of angular figures as are exhibited on the surface of this grand parade. From the infinite dissimilarity of the figure of these colums, this will appear a most surprising circumstance to the curious spectator; and would incline him to believe it a work of human art, was it not, on the other hand, inconceivable that the genius or invention of man should construct and combine such an infinite number of columns, which should have a general apparent likeness, and yet be so universally dissimilar in their figure, as that, from the minutest examination, not two in ten or twenty thousand should be found whose angles and sides are equal among themselves, or of the one column to those of the other. That it is the work of nature there can be no doubt to an attentive spectator, who carefully surveys the general form and situation, with the infinitely various configuration of the several parts of this causeway. There are no traces of regularity or design in the outlines of this curious phenomenon; which, including the broken and detached pieces of the same kind of workmanship, are extremely scattered and confused; and, whatever they might be originally, do not at present appear to have any connection with the grand or principal causeway, as to any supposable design or use in its first construction, and as little design can be inferred from the figure or situation of the several constituent parts. The whole exhibition is, indeed, extremely confused, ununiform, and destitute of every appearance of use or design in its original construction. But what, beyond dispute, determines its original to have been from nature is, that the very cliffs, at a great distance from the causeway, especially in the bay to the eastward, exhibit at many places the same kind of columns, figured and jointed in all respects like those of the grand causeway: some of them are seen near to the top of the cliff, which, in general, in these bays to the east and west of the causeway, is near 300 feet in height; others again are seen about midway, and at different elevations from the strand. A very considerable exposure of them is seen in the very bottom of the bay to the eastward, near 100 roods from the causeway, where the earth has evidently fallen away from them upon the strand, and exhibits a most curious arrangement of many of these pentagonal columns, in a perpendicular position, supporting, in appearance, a cliff of different strata of earth, clay, rock, &c. to the height of 150 feet or more, above. Some of these columns are between 30 and 40 feet high, from the top of the sloping bank below them; and being longest in the middle of the arrangement, shortening on either hand in view, they have obtained the appellation of organs, from a rude likeness in this particular to the exterior or frontal tubes of that instrument; and as there are few broken pieces on the strand near it, it is probable that the outside range of columns that now appears is really the original exterior line, toward the sea, of this collection. But how far they extend internally into the bowels of the incumbent cliff is unknown. The very substance, indeed, of that part of the cliff which projects to a point, between the two bays on the east and west of the causeway, seems composed of this kind of materials; for, besides the many pieces that are seen on the sides of the cliff that circulate to the bottom of the bays, particularly the eastern side, there is, at the very point of the cliff, and just above the narrow and highest part of the causeway, a long collection of them seen, whose heads or tops just appearing without the sloping bank, plainly show them to be in an oblique position, and about half way between the perpendicular and horizontal. The heads of these, likewise, are of mixed surfaces, convex and concave, and the columns evidently appear to have been removed from their original upright, to their present inclining or oblique position, by the sinking or falling of the cliff.

GIBBOUS, in astronomy, a term used in reference to the enlightened parts of the moon, whilst she is moving from the first quarter to the full, and from the full to the last quarter: for all that time the dark part appears horned or falcated, and the light one convex or gibbous.

GIBELINS, or GIBELLINS, a famous faction in Italy, opposite to another, called the Guelphs.

These two factions ravaged and laid waste Italy for a long series of years, so that the history of that country, for the space of two centuries, is no more than a detail of their mutual violence and slaughters. The Gibelins adhered to the emperor against the pope: but concerning their origin, and the reason of their names, we have but a very obscure account. According to the generality of authors, they rose about the year 1240, upon the emperor Frederic II's being excommunicated by pope Gregory IX. Other writers maintain, that the two factions arose ten years before, though still under the same pope and emperor. But the most probable opinion is that of Mainbourg, who says, that the two factions of Guelphs and Gibelins arose from a quarrel between two ancient and illustrious houses on the confines of Germany, that of the Henries of Gibeling, and that of the Guelphs of Adorf.

GIFT, a transferring the property in a thing from one to another without a valuable consideration; for to transfer any thing upon a valuable consideration is a contract of sale: he who gives any thing is called the donor: and he to whom it is given is called the donee.

By the common law all chattels, real or personal, may be granted or given, without deed, except in some spe-

cial cases; and a free gift is good without a consideration, if not to defraud creditors. Park 57.

But no leases, estates, or interests, either of freehold, or term of years, or any uncertain interest not being copyhold or customary interest, of, in, to, or out of, any messuage, manors, lands, tenements, hereditaments, shall at any time be assigned, granted or surrendered, unless it is by deed or act in writing, signed by the party so assigning, granting, or surrendering the same, or their agents thereunto lawfully authorised by writing, or by act and operation of law. 29 Car. II. c. 3. A gift of any thing without a consideration, is good: but it is revocable before delivery to the donee, of the thing given. Jenk. 109 pl. 9.

GILBERTINES, a religious order founded in England by St. Gilbert, in the reign of Henry I. The nuns followed the rule of St. Benedict, and the monks that of St. Augustin. There are many monasteries of this order in different parts of England.

GILD. See Geld.

Gild Merchant, was a certain privilege or liberty granted to merchants, whereby they were enabled, among other things, to hold certain pleas of land within their own precincts; as the gild-merchant granted by king John to the burgesses of Nottingham.

GILDING, is the application of gold to the surfaces of bodies: it is of two principal kinds, according to the method of applying the gold.

Wood, leather, paper, and similar substances, are gilt by fastening on leaves of gold by means of some cement. But metals are gilt by a chemical application of the gold to the surface. This last is called water-gilding.

The gilding of wood, and similar substances, is of three kinds: oil-gilding, burnished gilding, and japanners' gilding, which we shall severally describe, after noticing the materials and tools necessary for the operations.

Of gold-leaf.—There are three kinds of gold-leaf in common use. Pure gold-leaf, which is made by hammering gold till it is sufficiently thin (see Gold-beating). Pale leaf-gold, which has a greenish colour, and is made in the same way of gold alloyed with silver. Dutch gold, which is brought from Holland, and is in fact only copper-leaf coloured by the fumes of zinc. It is much cheaper than true leaf-gold, and is very useful where large quantities of gilding are wanted, which can be defended from the weather, and where great nicety is not required; but it changes its colour entirely when exposed to moisture; and indeed, in all cases, its beauty is soon impaired, unless well secured by varnish. It is therefore only a cheap substitute for true gold leaf, which may be useful where durability is not an object.

Of the instruments necessary for gilding.—The first instrument is the cushion, for receiving the leaves of gold from the books in which they are bought. It is made by covering a board of about eight inches square, with a double thickness of flannel: and over that a piece of buff leather, and fastening it tight round the edges.

The knife for cutting the leaves into the requisite sizes should be made like a pallet knife, and should not have its edge too sharp.

The tip is a tool made by fastening the long hairs of a squirrel's tail between two cards; and is used for taking up the gold-leaf after it is cut, and applying it to the article to be gilded.

A fitch pencil is used for the same purpose as the last, in taking up very small bits of gold-leaf. A ball of cotton is necessary for pressing down the leaf, after it is laid on. A large camel's-hair brush is used for dusting the work, and clearing away the superfluous gold.

Oil-gilding.—First prime your work with boiled linseed-oil and white-lead; and when that is dry, cover it over with a thin coat of gold size, made of stone-ochre ground in fat oil. When that is so dry as to feel clammy to the fingers, or to be what the gilders call tacky, it is fit for gilding. Having spread your leaves upon the cushion, cut them into slips of the proper width for covering your work. Then breathe upon your tip, which, by moistening it, will cause it to take up the leaves from the cushion. Having applied them by the tip on the proper parts of your work, press them down by the ball of cotton. Observe to repair, by putting small pieces of gold on, any parts which you have omitted to cover. When all your work is sufficiently covered, let it dry, and clean it off with the brush.

This sort of gilding is the easiest, least expensive, and stands the weather best, and may be cleaned with a little water at any time; but wants the lustre of burnished gilding.

Burnished gilding.—This is the sort of gilding generally used for picture-frames, looking-glasses, &c.

The wood intended to be gilt in this manner, should first be well sized, and then covered with seven or eight coats of size and whiting, so as to form a body of considerable thickness. Having got a sufficient quantity of whiting upon the work, it must be carefully cleaned, taking care to free all the cavities and hollows from the whiting that may have choked them up, and by proper moulds and tools restoring the sharpness of the mouldings intended to be shown.

It is then to receive a coat of size, which is made by boiling armenian bole with parchment size. This must also remain till it is sufficiently dry for gold. It must not be quite dry, therefore it would not be prudent to lay on more at a time than can be gilt before it becomes too dry.

The work being thus prepared, place it a little declining from you; and having ready a cup of clean water, and some hair-pencils, moisten a part of the work, and then apply the gold by the tip to the moistened part. The gold will immediately adhere close to the work: proceed to wet the next part, and apply the gold as before, repeating this operation till the whole is completed; taking care not to let any drops of water come upon any part of the gold already laid on. Care should therefore be taken that no part be missed in going over it at first, as it is not so easily mended as the oil-gilding.

The work being thus gilt, it is suffered to remain about 24 hours; when the parts that are designed to be burnished, are polished with a dog's tooth, or, what is better, with an agate burnisher. The gilding must not be quite dry when burnished; there is a state proper for the purpose, which is only to be known by experience.

Japanner's gilding.—The gilding of japanned work consists in drawing with a hair-pencil, in gold size, the intended ornaments, and afterwards applying gold-leaf, or gold powder.

The gold size may be prepared in the following man-

ner: Take of linseed oil, and of gum animi, four ounces. Set the oil to boil in a proper vessel, and then add the gum animi gradually in powder, stirring each quantity about in the oil till it appears to be dissolved, and then putting in another, till the whole is mixed with the oil. Let the mixture continue to boil, till, on taking a small quantity out, it appears of a thicker consistence than tar. and then strain the whole through a coarse cloth, and keep it for use; but it must, when applied, be mixed with vermilion and oil of turpentine.

Having laid on the gold size, and suffered it to dry, the gold-leaf is applied in the usual way; or if it is not wanted to shine so much, gold powder is applied, which is made by grinding gold-leaf upon a stone with honey, and afterwards washing the honey away with water. If the gilding is to be varnished over, Dutch gold may be used, or aurum musivum may be used instead of real gold powder.

To write on paper with letters of gold.—Put some gum arabic into common writing-ink, and write with it in the usual way. When the writing is dry, breathe on it; the warmth and moisture soften the gum, and will cause it to fasten on the gold-leaf; which may be laid on in the usual way, and the superfluous part brushed off. Or instead of this, any japanners' size may be used.

To lay gold upon white earthenware, or glass.—Procure some japanners' gold size, and with it draw your design upon the vessel to be gilt, moistening the gold size, as you find necessary, with oil of turpentine. Set your work in a clean place to dry, for about an hour, and then place it so near the fire, that you could but just bear the heat of it with your hand for a few seconds. Let it remain there till it feels quite tacky or clammy; then, having procured a cushion, and some leaf-gold, cut it into slips of the proper size, and lay it on with the little cotton ball. When the gold is all on, put the ware into an oven to be baked for two or three hours.

Glasses, &c. may also be gilt, by drawing the figures with shell gold mixed with gum arabic, and a little borax. Then apply sufficient heat to it; and, lastly, burnish it.

Gilding on glass or porcelain, by burning in.—Dissolve gold in aqua regia, and evaporate the acid by heat, you will obtain a gold powder; or precipitate the gold from the solution by pieces of copper. Lay this gold on with a strong solution of borax and gum water, and it will be ready for burning-in.

Gilding metals.—One method of applying gold upon metals is by first cleaning the metal to be gilt; then gold-leaf is laid on it, which, by means of rubbing with a polished blood-stone, and a certain degree of heat, are made to adhere perfectly well. In this manner silver-leaf is fixed and burnished upon brass, in the making of what is called French plate; and sometimes also gold-leaf is burnished upon copper and iron.

Gilding by amalgamation. A better method is, by previously forming the gold into paste, or amalgam, with mercury.

In order to obtain an amalgam of gold and mercury, the gold is first to be reduced into thin plates or grains, which are heated red-hot, and thrown into mercury previously heated, till it begins to smoke. Upon stirring the mercury with an iron rod, the gold totally disappears. The proportion of mercury to gold is generally as six or eight to one.

The method of gilding by amalgamation is chiefly used for gilding copper, or an alloy of copper, with a small portion of zinc, which more readily receives the amalgam. and is also preferable on account of its colour, which more resembles that of gold than the colour of copper.

When the metal to be gilt is wrought or chased, it ought to be previously covered with quicksilver before the amalgam is applied. that this may be easier spread; but when the surface of the metal is plane, the amalgam may be directly applied to it.

The metal required to be gilt is first rubbed over with a little aquafortis, by which the surface is cleaned from any rust or tarnish that might prevent the union of the two metals. The amalgam being then equally spread over the surface by means of a brush, the mercury is evaporated by a heat just sufficient for that purpose; for if it is too great, part of the gold may also be expelled, and part of it will run together, and leave some of the surface of the metal bare. While the mercury is evaporating the piece is to be, from time to time, taken from the fire, that it may be examined; that the amalgam may be spread more equally by means of a brush; that any defective parts of it may be again covered, and that the heat may not be too suddenly applied to it. When the mercury is evaporated, which is known by the surface becoming entirely of a dull yellow-colour, the metal must then undergo other operations, by which the fine gold-colour is given to it.

First, the gilded piece of metal is rubbed with a scratch-brush (which is a brush composed of brass wire) till its surface is made smooth; then it is covered over with a composition called gilding wax, and is again exposed to the fire till the wax is burnt off. This wax is composed of bee's-wax, frequently mixed with some of the following substances: red ochre, verdigris, copper scales, alum, vitriol, borax; but, according to Dr. Lewis, the saline substances are sufficient, without any wax.

By this operation the colour of the gilding is heightened; and the effect seems to be produced by a perfect dissipation of some mercury remaining after the former operations.

The gilt surface is then covered over with a saline composition, consisting of nitre, alum, or vitriolic salt, ground together, and mixed up into a paste with water or urine. The piece of metal thus covered is exposed to a certain degree of heat, and then quenched in water. By this method its colour is further improved, and brought nearer to that of gold. This effect seems to be produced by the acid of the nitre, (which is disengaged by the sulphuric acid of the alum during the exposure to heat) acting upon any particles of copper which may happen to lie upon the gilded surface.

Lastly. Some artists think that they give an additional lustre to their gilt work, by dipping it in a liquor prepared by boiling some yellow materials, as sulphur, orpiment, or turmeric. The only advantage of this operation is, that part of the yellow matter remains in some of the hollows of the carved work, in which the gilding

is apt to be more imperfect, and to which it gives a rich and solid appearance.

It may here be noticed, that the use of the aquafortis or nitric acid, mentioned in the beginning of the process, is not, as is generally supposed, confined merely to cleansing the surface of the metal to be gilt from rust or tarnish; but it also greatly facilitates the application of the amalgam to the surface of that metal, probably in the following manner: It first dissolves part of the mercury of the amalgam; and when the solution is applied to the copper, this latter metal, having a stronger disposition to unite with the nitrous acid than the mercury has, precipitates the mercury upon its surface, in the same manner as a polished piece of iron precipitates upon its surface copper from a solution of blue vitriol. When the metal to be gilt is thus covered with a thin coat of precipitated mercury, it readily receives the amalgam.

On the subject of gilding by amalgamation, Dr. Lewis has the following remarks: "There are two principal inconveniences in this business; one, that the workmen are exposed to the fumes of the mercury, and generally, sooner or later, have their health greatly impaired by them; the other, the loss of the mercury; for though part of it is said to be detained in the cavities made in the chimneys for that purpose, yet the greatest part of it is lost. From some trials I have made, it appeared that both these inconveniences, particularly the first and most considerable one, might be in a good measure avoided, by means of a furnace of due construction."

If the communication of a furnace with its chimney, instead of being over the fire, is made under the grate, the ash-pit door, or other apertures beneath the grate, closed, and the mouth of the furnace left open, the current of air, which otherwise would have entered beneath, enters now at the top, and passing down through the grate to the chimney, carries with it completely both the vapour of the fuel, and the fumes of such matters as are placed upon it. The back part of the furnace should be raised a little higher above the fire than the fore part, and an iron plate laid over it, that the air may enter only at the front, where the workman stands, who will be thus effectually secured from the fumes, and from being incommoded by the heat, and at the same time have full liberty of introducing, inspecting, and removing, the work.

If such a furnace is made of strong forged (not milled) iron plate, it will be sufficiently durable. The upper end of the chimney may reach above a foot and a half higher than the level of the fire; over this is to be placed a larger tube, leaving an interval of an inch, or more, all round between it and the chimney, and reaching to the height of ten or twelve feet; the higher the better. The external air, passing up between the chimney and the outer pipe, prevents the latter from being much heated, so that the mercurial fumes will condense against its sides into running quicksilver, which falling down to the bottom, is there caught in a hollow rim, formed by turning inwards a portion of the lower part, and conveyed by a pipe at one side into a proper receiver.

Gilding iron or steel. In gilding iron or steel by means of an amalgam, as the metal has no affinity for the mercury, an agent must be employed to dispose the surface to receive the gilding. For this purpose a solution of mercury in nitrous acid (aquafortis), or what the workmen call quicksilver water, is applied to the parts intended to be gilded; the acid, by a stronger affinity, seizes on a portion of the iron, and deposits in the place of it a thin coating of mercury, which will not refuse an union afterwards with the gold amalgam that may be applied; but by this process the surface of the metal is injured by the nitrous acid, and the union of the mercury is very slight, so that a bright and durable gilding cannot be obtained.

Another method. Sometimes a solution of blue vitriol is applied, with a camel's-hair pencil, to the parts of the steel intended to be gilt. By a chemical action, exactly similar to what we have described as taking place when a solution of nitrate of mercury is employed, a thin coating of copper is precipitated on the metal. Copper having an affinity for mercury, a kind of union may by this means be effected between the amalgam and the iron or steel, as the case may be. In whichever of these methods the amalgam is brought into union with the steel, the surface is injured by the action of the acid employed, and still a heat sufficient to volatilize the mercury must be afterwards used.

Gilding of iron by heat. When the surface is polished bright, it must be heated till it becomes blue. Gold leaf is then applied to its surface, and burnished down. It is then heated again, and another layer of gold burnished on it. In this manner three or four coats are given, according to the strength of the gilding intended. This is a more laborious process than the two last, but it is not attended with so much risk.

An improved process for gilding iron or steel. This process, which is less known among artists than it deserves to be, may prove useful to those who have occasion to gild iron or steel. The first part of the process consists in pouring over a solution of gold in nitro-muriatic acid (aqua regia) about twice as much ether, which must be done with caution, and in a large vessel. These liquids must then be shaken together; as soon as the mixture is at rest, the ether will be seen to separate itself from the nitro-muriatic acid, and to float on the surface. The nitro-muriatic acid becomes more transparent, and the other darker than they were before; the reason of which is, that the ether has taken the gold from the acid. The whole mixture is then to be poured into a glass funnel, the lower aperture of which is small; but this aperture must not be opened till the fluids have completely separated themselves from each other. It is then to be opened; by which means the liquid which has taken the lowest place by its greater gravity, viz. the nitro-muriatic acid, will run off: after which, the aperture is to be shut, and the funnel will then be found to contain nothing but ether mixed with the gold, which is to be put into well-closed bottles, and preserved for use. In order to gild iron or steel, the metal must be first well polished with the finest emery, or rather with the finest crocus martis or colcothar of vitriol, and common brandy. The auriferous ether is then to be applied with a small brush; the ether soon evaporates, and the gold remains on the surface of the metal. The metal may then be put into the fire, and afterwards polished. By means of this auriferous ether, all kinds of figures may be delineated on iron, by employing a pen, or fine brush. It is in this

manner, we believe, that the Sohlinger sabre-blades are gilded.

Instead of ether, the essential oils may be used, such as oil of turpentine, or oil of lavender, which will also take gold from its solution.

Gilding of silver. Dissolve gold in the nitro-muriatic acid, and dip some linen rags in the solution; then burn them, and carefully preserve the ashes, which will be very black, and heavier than common. When any thing is to be gilded, it must be previously well burnished; a piece of cork is then to be dipped, first into a solution of salt in water, and afterwards into the black powder; and the piece, after being rubbed with it, must be burnished. The powder is frequently used for gilding delicate articles of silver.

Gilding of brass and copper. Fine instruments of brass, in order that their surface may be kept longer clean, may be gilded in the following manner.

Provide a saturated solution of gold, and having evaporated it to the consistence of oil, suffer it to shoot into crystals. These crystals must then be dissolved in pure water, and the articles to be gilded being immersed in it, are then to be washed in pure water, and afterwards burnished. This process may be repeated several times, till the articles have been well gilt. A solution of gold crystals is preferred to a mere solution of gold, because in the latter there is always a portion of free acid, which will not fail to exercise more or less action on the surface of the brass or copper, and injure its polish.

Grecian gilding. Dissolve some mercury in muriatic acid (spirit of salt), which will give a muriate of mercury. Mix equal parts of this and sal ammoniac, and dissolve them in aquafortis. Put some gold into this, and it will dissolve. When this is applied to silver, it becomes black; but by heating, it assumes the appearance of gilding.

To make shell-gold. Grind up gold-leaf with honey in a mortar; then wash away the honey with water, and mix the gold powder with gum water. This may be applied to any article with a camel's-hair pencil, in the same way as any other colour.

GILT-HEAD. See Sparus.

GIMBALS, a contrivance by means of which barometers, vessels of oil, mariner's compasses, &c. may be suspended so as to arrange their upper parts horizontally. The nature of this contrivance will be at once understood by showing its application to a mariner's compass. It consists of a hoop or ring supported upon two pins diametrically opposite each other, and issuing from the external surface of the ring in such a direction that both lie in the same diametrical line. When the hoop is suspended on these pins, it is at liberty to turn freely about the diameter, of which they constitute the prolongation. The notches or holes of support are disposed horizontally. The compass-box itself is placed in a similar ring with two projecting pivots: and these pivots are inserted in holes made in the former ring at equal distances from each of its pivots. If therefore the whole is left at liberty, the compass-box may vibrate upon the diametrical line of the outer ring, as well as opon a line formed by its own pivots, at right angles to that diametrical line. The consequence of this arrangement is, that the centre of gravity of the compass-box will dispose itself immediately beneath the intersection of both lines on which it is at liberty to move: that is, if the weight of the box and its component parts are properly disposed, the compass will assume a position in which the surface shall be horizontal.

GIN. See Distillation.

Gin, in mechanics, a machine for driving piles, fitted with a windlass and winches at each end, where eight or nine men heave, and round which a rope is reeved, that goes over the wheel at the top: one end of this rope is seized to an iron monkey, that hooks to a beetle of different weights, according to the piles they are to drive, being from eight to thirteen hundred weight; and when hove up to a cross-piece near the wheel it unhooks the monkey, and lets the beetle fall on the upper end of the pile, and forces the same into the ground; then the monkey's own weight overhauls the windlass, in order for its being hooked again to the beetle.

GINANNIA, a genus of the class and order enneandria monogynia. The calyx is double, both one leaved; petals three fringed and spreading; germ pedicelled, with a membranaceous wing at top. Legume. There is one species, a shrub of Guiana.

GINKGO, or maidenhair-tree, of the dioecia class (order and character unknown), a large tree of Japan, with leaves resembling the adiantum, whence its popular name.

GINORA, a genus of the dodecandria monogynia class and order. The calyx is six-clefted; petals six; capsules one-seeded, four-celled, four-valved, coloured, many seeds. There is one species, an elegant shrub of Cuba, bearing handsome large red flowers.

GINGER. See Amomum.

GINSENG. See Panax.

GIRDERS, in architecture, some of the largest pieces of timber in a floor.

By the building act, no girder is to lie less than 10 inches into the wall, and the ends to be laid in loam.

GIRDING-GIRT, in the sea language. A ship is girt, or has a girding-girt, when her cable is so tight or strained, upon the turning of the tide, that she cannot get over it, but lies across the tide.

GIRONNE', or Gironny, in heraldry, a coat of arms divided into girons or triangular figures, meeting in the centre of the shield, and alternately colour and metal.

GISEKIA, a genus of the class and order pentandria pentagynia. The calyx is five-leaved; corolla none; capsules five, approximating, roundish, one-seed. There is one species, an annual of the East Indies.

GLABRASIA, a genus of the class and order polyadelphia polyandria. The calyx is five-cleft; nectarium composed of bristles; stamina 30, always in sixes; perianthium a drupe. There is one species, a large tree of the East Indies.

GLACIES MARIÆ. See Mica.

GLACIS, in fortification, that mass of earth which serves as a parapet to the covered way, sloping easily towards the champaign or field. See Fortification.

GLADIATORS, in antiquity, persons who fought generally in the arena at Rome, for the entertainment of the people.

The gladiators were usually slaves, and fought out of necessity, though sometimes freemen made profession of

it, like our prize fighters, for a livelihood. The Romans borrowed this cruel diversion from the Asiatics. They were all first sworn that they would fight till death; and if they failed they were put to death either by fire, swords, clubs, whips, &c. It was usual with the people or emperor to grant them life when they showed no signs of fear. Augustus decreed that it should always be granted them.

After the engagement, several marks of favour were conferred on the victor, particularly a branch of palm-tree; and often a sum of money, perhaps gathered up among the spectators; but the most common rewards were the pileus and the rudis; the former being given only to such gladiators as were slaves, for a token of obtaining their freedom, but the rudis seems to have been bestowed both on slaves and freemen, with this difference, that it procured the former no more than a discharge from any further performance in public: the rudis, when given to such persons as, being free, had hired themselves out for these shows, restored them to a full enjoyment of their liberty.

From slaves and freedmen, the wanton sport spread to persons of rank, as we find in Nero's time. And Domitian exhibited combats of women in the night-time. We also read that dwarfs encountered with one another. Constantine the Great first prohibited these combats in the East; but the practice was not entirely abolished in the West before Theodoric king of the Ostrogoths, in the year 500.

The dying Gladiator, is a most valuable monument of ancient sculpture, which is now preserved in the palace of Chighi. This man, when he had received the mortal stroke, is particularly careful *ut procumbat honeste*, that he might fall honourably. He is seated in a reclining posture on the ground, and has just strength sufficient to support himself on his right arm; and in his expiring moments it is plainly seen that he does not abandon himself to grief and dejection, but is solicitous to maintain that firmness of aspect which the gladiators valued themselves on preserving in this season of distress, and that attitude which they had learnt of the masters of defence. He fears not death, nor seems to betray any tokens of fear by his countenance, nor to shed one tear. We see, in this instance, notwithstanding his remaining strength, that he has but a moment to live; and we view him with attention, that we may see him expire and fall. Thus the ancients knew how to animate marble, and to give it almost every expression of life.

GLADIOLUS, *corn flag*, a genus of the monogynia order, in the triandria class of plants, and in the natural method ranking under the sixth order, ensatæ. The corolla is sexpartite and ringent, the stamina ascending and bending upwards. There are thirty species, of which the most generally known is the communis or common gladiolus. This has a round, compressed, tuberous root, long sword-shaped leaves, an erect flower-stalk, two or three feet high, the top adorned with several pretty large flowers of a red or white colour, having each six petals. They appear in May and June, and are succeeded by plenty of seed in August. The plants are very hardy, and will thrive in any soil or situation. They are propagated by offsets from the roots. The gladiolus cordinalis is a bulb of the Cape, exquisitely beautiful.

GLAMA. See Camelus.

GLAND. See Anatomy.

GLANDERS. See Farriery.

GLAREOLA, in ornithology, a genus of birds of the order of grallæ. The generic character is: bill strong, short, straight, hooked at the tip; nostrils at the base of the bill linear, oblique; gape of the mouth large; feet four-toed; toes long, slender, connected at the base by a membrane; tail forked, consisting of 12 feathers. There are three species. The austriaca inhabits the heaths of Europe near the banks of rivers, is about nine inches long, feeds on worms and aquatic insects, is very restless and clamorous. See Plate LXVII. Nat. Hist. fig. 214. The senegallensis is found near the Senegal, and in several parts of Siberia: and the nævia is to be met with only in Germany.

GLASS, a transparent, brittle, factitious body, produced by the action of fire upon a fixed salt and sand, or stone, that readily melts.

The fixed alkalies have a strong affinity for several of the earths, particularly for silica and alumina, which they dissolve in considerable quantity, when assisted by heat. When a strong heat is applied to a mixture of fixed alkali and silica, it melts, and forms a transparent mass well known by the name of glass.

The method of making this useful compound was known at an early period. According to Pliny, the discovery was owing to an accident. Some merchants, with a ship-load of soda from Egypt, had cast anchor at the mouth of the river Belus in Phœnicia, and were dressing their dinner on the sand. They made use of large lumps of soda to support their kettles, and lighted fires under them. The heat melted the soda and the siliceous sand together, and the result was glass.

For some time after this accidental discovery, the manufacture of glass was confined to the river Belus. This manufacture seems to have been carried to a considerable degree of perfection among the ancients. They mention drinking-glasses, glass prisms, and coloured glasses of various kinds. But perfectly transparent glass was considered as very valuable; for Nero gave 50,000*l*. for two glass cups with handles; a proof that their processes must have been far less perfect than ours. It was usual for them to melt the materials of their glass into a black mass called ammonitrum, of which statues were sometimes made. This ammonitrum was again melted and purified by refiners. Glass panes seem to have been first used in windows in the third century; but they did not come into common use till long after.

The materials employed in the manufactory of glass may be reduced under three classes, namely, alkalies, earths, and metallic oxides.

The fixed alkalies may be employed indifferently; but soda is preferred in this country. The soda of commerce is usually mixed with common salt, and combined with carbonic acid. It is proper to purify it from both of these foreign bodies before using it. This, however, is seldom done.

The earths are silica, lime, and sometimes a little alumina. Silica constitutes the basis of glass. It is employed in the state of fine sand or flints; and sometimes

for making very fine glass, rock crystal is employed. When sand is used, it ought if possible to be perfectly white; for when it is coloured with metallic oxides, the transparency of the glass is injured. Such sand can only be employed for very coarse glasses. It is necessary to free the sand from all the loose earthy particles with which it may be mixed, which is done by washing it well with water.

Lime renders glass less brittle, and enables it to withstand better the action of the atmosphere. It ought in no case to exceed the twentieth part of the silica employed, otherwise it corrodes the glass pots. This indeed may be prevented by throwing a little clay into the melted glass; but in that case a green glass only is obtained.

The metallic oxides employed are the red oxide of lead or litharge, and the white oxide of arsenic. The red oxide of lead, when added in sufficient quantity, enters into fusion with silica, and forms a glass without the addition of any other ingredient. Five parts of minium and two of silica form a glass of an orange-colour and full of striæ. Its specific gravity is 5. The red oxide of lead renders glass less brittle and more fusible; but when added beyond a certain proportion, it injures the transparency and the whiteness of glass.

The white oxide of arsenic answers the same purposes with that of lead; but on account of its poisonous qualities it is seldom used. It is customary to add a little nitre to the white oxide of arsenic, to prevent the heat from reviving it, and rendering it volatile. When added beyond a certain proportion, it renders glass opaque and milky like the dial-plate of a watch. When any combustible body is present, it is usual in some manufactures to add a little white oxide of arsenic. This supplying oxygen, the combustible is burnt, and flies off; while the revived arsenic is at the same time volatilized.

After mixing the alkali and sand together, it is usual to expose them for some time to a moderate heat. This serves several purposes. It drives off all combustible bodies which may happen to be mixed with the sand; it produces a commencement of combustion which makes the glass afterwards less liable to corrode the clay pots in which it is melted; and the alkali, by this incipient combination, is not so apt to be volatilized, which might be the case if the materials were exposed at once to a violent heat. The mixture, after being thus heated, is called the frit. Through the domes in which the frit is heated, it is usual to see very thin bubbles of glass passing: a proof that some of the materials are volatilized during this first part of the process.

The frit, while still hot, is introduced into large pots made of a mixture of pure clay, and exposed to a heat sufficient to melt it completely. The fusion must be continued till the effervescence occasioned by the separation of the carbonic acid from the soda has subsided, and the opaque scum, known by the name of glass-gall, which collects on the surface of the glass, must be removed. This scum is occasioned by the common salt and other foreign bodies which are always mixed with the soda of commerce. When the fusion has been continued the proper time, the furnace is allowed to cool a little. In that state the glass is exceedingly ductile, and readily assumes any shape that the workmen pleases.

If the glass vessels, after being formed, were cooled rapidly, they would contract unequally, and become in consequence so brittle as to fall to pieces whenever they were handled. To prevent this inconvenience, they are put into a large red-hot furnace, which is allowed to cool very slowly to the temperature of the air. This process is called annealing.

The properties that distinguish good glass are well known. It is perfectly transparent; its hardness is very considerable; its specific gravity varies from 2.8 to 4, according to the proportion of metallic oxide which it contains. When cold it is brittle; but at a red heat it is one of the most ductile bodies known, and may be drawn out into threads so fine as to be scarcely visible to the naked eye. (See Ductility.) It is almost perfectly elastic, and of course is one of the most sonorous of bodies. There are but few chemical agents which have any action on it. Fluoric acid dissolves it with great rapidity, and so do the fixed alkalies when assisted by heat. Dr. Priestley has shown also, that the long-continued action of hot water is capable of decomposing it; a discovery which explains sufficiently the siliceous earth obtained by Boyle and Margraff, when they subjected water to tedious distillations in glass vessels.

There are different kinds of glass manufactured for different purposes: the principal of these are flint glass, crown glass, and bottle glass.

Flint glass is formed of soda, pounded flints, and oxide of lead. It is the densest, most transparent, and most beautiful glass, and is often called crystal. Crown glass contains no lead. It is composed of soda and fine sand. This kind is used for the panes of windows. Bott'e glass is the coarsest of all. It is composed of kelp, or the refuse of soap-boilers, and common sand. Its green colour is owing to the presence of iron. Of these species the most fusible is flint glass, and the least fusible bottle glass. According to the experiments of Saussure, flint glass melts at the temperature of 19° Wedgewood, crown glass at 30°, and bottle glass at 47°.

Glass is often tinged of various colours by mixing with it while in fusion some one or other of the metallic oxides; and on this process, well conducted, depends the formation of pastes or factitious gems.

Blue glass is formed by means of oxide of cobalt.

Green, by the oxide of iron or of copper.

Violet, by oxide of manganese.

Red, by a mixture of the oxides of copper and iron.

Purple, by the purple oxide of gold.

White, by the oxide of arsenic and zinc.

Yellow, by the oxide of silver and by combustible bodies.

Opticians, who employ glass for optical instruments, often complain of the many defects under which it labours. The chief of these are the following:

Streaks. These are waved lines, often visible in glass, which interrupt distinct vision. They are probably owing sometimes to want of complete fusion, which prevents the different materials from combining sufficiently; but in some cases also they may be produced by the workmen lifting up, at two different times, the glass which is to go to the formation of one vessel or instrument.

Tears. These are white specks or knots, occasioned by

the vitrified clay of the furnaces, or by the presence of some foreign salt.

Bubbles. These are air bubbles which have not been allowed to escape. They indicate want of complete fusion, either from too little alkali, or the application of too little heat.

Cords. These are asperities on the surface of the glass, in consequence of too little heat.

Blowing of glass vessels. The furnace for this (fig. 5. Plate Manufacture of Glass) has several mouths, according to the number of workmen. Each mouth consists of three holes, ABD; D is a hole through which the workman takes his metal from the melting-pot; A is the hole at which he afterwards heats his metal; and B is a small hole at which he heats the ends of his blowing-pipe and iron rods *aa*, which are supported by an iron bar across the mouth of the furnace. The furnace is built of fire-bricks, and has three domed chambers, one above another, within it; the fire is made upon a large grate in the middle of the lower one, to which the air is admitted by an arch under ground; the flame goes through an opening in the dome of this chamber, and strikes against the top of the next chamber, and is thereby reverberated upon the pots, which stand upon the floor, just within the hole D; the smoke goes through the floor and roof of the next chamber, which is used as an annealing oven. This furnace is inclosed within a large building, like an inverted funnel, with a chimney at the top.

The principal implements used by the glass-blower are, a blowing-pipe, fig. 1, which is an iron pipe about two feet long, with rope-yarn wrapped round it at A, where the workman takes hold of it; two or three iron rods, fig. 2, of the same length; a pair of blunt shears, fig. 3; and several different sized ladles, shovels, pokers, &c. He has also two stools, figs. 6 and 7, to be hereafter described.

For explaining the operation, we shall describe the method of making a goblet. The workman dips the end D of his blowing-pipe, fig. 1, which is hot, through the hole D, fig. 5, into the melting-pot, which contains the glass in a state of fusion; and by turning it about, a small quantity of the glass, which is called metal, sticks to the iron: this he repeats three or four times (between each dip rolling it on an iron plate, fixed on the stool, fig. 7, to bring it into form) till he has got metal enough: he then blows at the end B of the pipe, which expands the metal into a hollow globular form; and then by swinging it round his head, it lengthens out in the shape of a bladder. The workman then sits down on the stool, fig. 6, between the two bars H and I, across which he lays the blowing-iron, and rolls it along under his left hand, following it at the same time with the shears, fig. 3, in his right hand, the blades *nn* of which embrace it, and by gently putting them in the proper place, he brings the glass into the form shown in fig. 10; meanwhile, the boy who attends him brings a lump of metal from the furnace on the end of one of the iron rods fig. 2, which he sticks on the bottom, or part *a*, fig. 10, and by twisting the rod round, he separates the metal from the rod, and leaves it on the glass vessel; the workman then rolls the rod and vessel as before, and with his shears, as shown in fig. 9, brings the lumps of glass into the form of a stem and foot, as there described. The boy then holds the tool, fig. 4, against the bottom of the foot *b*, while it is turning, to flatten it. The boy next takes another iron rod, fig. 2, and gets a very small piece of metal on its end: this he applies to the centre of the bottom of the foot, so as to connect it to the rod; when the workman, by touching it at the neck *d* with a wet iron, cracks the glass, so that a slight blow upon the rod with the hand will separate it at *d*, from the blowing-pipe M. The glass has by this time become too cold to work without heating again, which is done before the fire A, fig. 5; the workman then returns to the stool, fig. 6, and again rolls the rod round with his left hand as before, and with the point of one of the blades *n* of the shears opens the end *d*, fig. 8, of the glass; after which he inserts both points, and finally works it into the form of fig. 13. It is now separated from the rod N, and is carried on a shovel like a baker's peel by the boy to the annealing furnace, where it remains in a low red-heat for many hours, by which its former extreme brittleness is removed.

Window-glass is made in a similar manner, except that the liquid mass at the end of the tube is formed into a cylindrical shape, which being cut longitudinally by scissars or shears, is gradually bent back until it becomes a flat plate.

Large plate-glass for looking-glasses, &c. is made by suffering the mass in a state of complete fusion to flow upon a table, with iron ledges to confine the melted matter, and as it cools a metallic roller is passed over it, to reduce it to an uniform thickness.

Good glass ware is often ornamented by the glass-cutter before it is offered for sale (see fig. 12); this is generally performed by a machine, fig. 14, wherein AA is a large wheel to be turned by a man at the winch B. The band of this wheel passes round a pulley *a* on the axle of a wheel or cutter C, and thereby turns it with a great velocity: beneath the cutter a cistern D is placed, and above it a small cask E to contain water, the cock *b* of which is so placed and adjusted as to drop very slowly on the circumference of the cutter. The glass-grinder sits down on the stool F, and after dressing the edge of the cutter with emery paste, he applies successively the parts of the glass which are to be cut, as shown in fig. 11, and dexterously moves the glass, as the parts intended to be cut are sufficiently ground away: after this another similar cutter is applied instead of C, or the same is dressed with finer emery paste, or mixture of tripoli and other polishing powders, in order to polish the parts which have been cut; such parts as are intended to have a white appearance are left rough. The cutters *c* are formed of hard wood or soft metal, and the workman is provided with several, of different sizes and thicknesses, particularly at the edge, according to the device which is to be cut on the glass. It is by the fine edge of these cutters that letters, flowers, &c. are cut on glasses by dexterous workmen.

Glass, *painting on.* A few years since, Mr. Farrant obtained a patent for painting, spangling, gilding, and silvering glass, which was performed on the back of the crystal or glass, so as when finished to appear on the front; the colours prepared in oil or varnish as in other works. The parts of ornament which are gold must be first shadowed on the glass, and when dry the gold leaf

must be laid on. Silver ornament is to be done in the same manner. For the spangling, leave the parts to be spangled to the last; then shadow them, and when dry varnish the parts with copal varnish, and strew the spangles on while it is wet; when they are dry, varnish them two or three times.

The ancient manner of painting in glass was very simple, and consequently very easy: it consisted in the mere arrangement of pieces of glass of different colours in some sort of symmetry, and constituted what is now called mosaic work.

In process of time they came to attempt more regular designs, and also to represent figures heightened with all their shades: yet they proceeded no farther than the contours of the figures in black with water colours, and hatching the draperies after the same manner on glasses of the colour of the object they designed to paint. For the carnation, they used glass of a bright-red colour, and upon this they drew the principal lineaments of the face, &c. with black.

But in time, the taste for this sort of painting, improving considerably, and the art being found applicable to the adorning of churches, &c. they found out means of incorporating the colours in the glass itself, by heating them in the fire to a proper degree, having first laid on the colours. The colours used in painting or staining of glass are very different from those used in painting either in water or oil colours.

For black, take scales of iron one ounce, scales of copper one ounce, jet half an ounce; reduce them to powder, and mix them. For blue, take powder of blue one pound, sal nitre half a pound; mix them, and grind them well together. For carnation, take red chalk eight ounces, iron scales and litharge of silver of each two ounces, gum arabic half an ounce; dissolve in water; grind all together for half an hour as stiff as you can; then put it in a glass and stir it well, and let it stand to settle 14 days. For green, take red lead one pound, scales of copper one pound, and flint five pounds; divide them into three parts, and add to them as much nitre; put them into a crucible and melt them with a strong fire; and when it is cold, powder it, and grind it to a porphyry. For gold colour, take silver an ounce, antimony half an ounce; melt them in a crucible; then pound the mass to powder, and grind it on a copper plate; add to it yellow ochre, or brick-dust calcined again, 15 ounces, and grind them well together with water. For purple, take minium one pound, brown stone one pound, white flint five pounds; divide them into three parts, and add to them as much nitre as one of these parts; calcine, melt, and grind it as you did the green. For red, take jet four ounces, litharge of silver two ounces, red chalk one ounce; powder them fine and mix them. For white, take jet two parts, white flint, ground on a glass very fine, one part, mix them. For yellow, take Spanish brown ten parts, leaf silver one part, antimony half a part; put all into a crucible, and calcine them well.

In the windows of ancient churches, &c. there are to be seen the most beautiful and vivid colours imaginable, which far exceed any of those used by the moderns, not so much because the secret of making those colours is entirely lost, as that the moderns will not go to the charge of them, nor be at the necessary pains. Those beautiful works which were made in the glass-houses were of two kinds.

In some, the colour was diffused through the whole substance of the glass. In others, which were the more common, the colour was only on one side, scarcely penetrating within the substance above one third of a line; though this was more or less according to the nature of the colour, the yellow being always found to enter the deepest. These last, though not so strong and beautiful as the former, were of more advantage to the workmen, since on the same glass, though already coloured, they could show other kind of colours where there was occasion to embroider draperies, enrich them with foliage, or represent other ornaments of gold, silver, &c.

In order to this, they made use of emery, grinding or wearing down the surface of the glass, till they were got through the colour to the clear glass. This done, they applied the proper colours on the other side of the glass. By this means, the new colours were hindered from running and mixing with the former, when they exposed the glasses to the fire, as will appear hereafter.

When, indeed, the ornaments were to appear white, the glass was only bared of its colour with emery, without tinging the place with any colour at all; and this was the manner by which they wrought their lights and heightenings on all kinds of colour.

The first thing to be done in order to paint or stain glass in the modern way, is to design and even colour the whole subject on paper. They then choose such pieces of glass as are clear, even, and smooth, and proper to receive the several parts, and proceed to distribute the design itself, or papers it is drawn on, into pieces suitable to those of the glass; always taking care that the glasses may join in the contours of the figures and the folds of the draperies; that the carnations and other finer parts may not be impaired by the lead with which the pieces are to be joined together. The distribution being made, they mark all the glasses as well as papers, that they may be known again; which done, applying every part of the design upon the glass intended for it, they copy or transfer the design upon this glass with the black colour diluted in gum water, by tracing and following all the lines and strokes as they appear through the glass with the point of a pencil.

When these strokes are well dried, which will happen in about two days, the work being only in black and white, they give a slight wash over with urine, gum arabic, and a little black, and repeat it several times, according as the shades are desired to be heightened, with this precaution never to apply a new wash till the former is sufficiently dried.

This done, the lights and risings are given by rubbing off the colour in the places with a wooden point, or the handle of the pencil.

As to the other colours above-mentioned, they are used with gum-water, much as in painting in miniature, taking care to apply them lightly for fear of effacing the outlines of the design; or even, for the greater security, to apply them on the other side; especially yellow, which is very pernicious to the other colours, by blending with them. And here too, as in pieces of black and white, particular regard must always be had not to lay colour

on colour, or lay on a new lay till such time as the former are well dried.

It may be added, that the yellow is the only colour that penetrates through the glass, and incorporates with it by the fire; the rest, and particularly the blue, which is very difficult to use, remaining on the surface, or at least entering very little. When the painting of all the pieces is finished, they are carried to the furnace or oven, to anneal or bake the colours.

The furnace here used is small, built of brick, from 18 to 30 inches square; at six inches from the bottom is an aperture to put in the fuel, and maintain the fire. Over this aperture is a grate, made of three square bars of iron, which traverse the furnace, and divide it into two parts. Two inches above this partition is another little aperture, through which they take out pieces to examine how the coction goes forward. On the grate is placed a square earthen pan, six or seven inches deep, and five or six inches less every way than the perimeter of the furnace. On the one side is a little aperture, through which to make trials, placed directly opposite to that of the furnaces destined for the same end. In this pan are the pieces of glass to be placed in the following manner: First, the bottom of the pan is covered with three strata or layers, of quick lime pulverized; those strata being separated by two others of old broken glass, the design of which is to secure the painted glass from the too intense heat of the fire. This done, the glasses are laid horizontally on the last or uppermost layer of lime.

The first row of glass they cover over with a layer of the same powder, an inch deep; and over this they lay another range of glasses, and thus alternately till the pan is quite full, taking care that the whole heap always end with a layer of the lime-powder.

The pan being thus prepared, they cover up the furnace with tiles, on a square table of earthenware, closely luted all round, only leaving five little apertures, one at each corner, and another in the middle, to serve as chimneys. Things thus disposed, there remains nothing but to give the fire to the work. The fire for the first two hours must be very moderate, and must be increased in proportion as the coction advances, for the space of ten or twelve hours, in which time it is usually completed. At last the fire, which at first was charcoal, is to be of dry wood, so that the flame covers the whole pan, and even issues out at the chimneys.

During the last hours, they make essays, from time to time, by taking out pieces laid for the purpose through the little aperture of the furnace and pan, to see whether the yellow is perfect, and the other colours in good order. When the annealing is thought sufficient, they proceed with great haste to extinguish the fire, which otherwise would soon burn the colours, and break the glasses.

By several statutes, regulations are made for making, importing, and exporting glass, which is to be under the management of the officers of the customs and excise. See Complete Abridgement of the Excise Laws.

GLAUBER's SALT, a cathartic or purging salt. See SODA, *sulphat of.*

GLAUCOPIS, in ornithology, a genus of birds of the order picæ. Bill incurvate, arched, the lower mandible shorter, and carunculate beneath at the base, nostrils depressed, half-covered with a membrane; tongue slit, and fringed at the tip; feet walkers. It inhabits New Zealand.

GLAUX, *milkwort*, a genus of the monogynia order, in the pentandria class of plants, and in the natural method ranking under the 17th order, calycanthemæ. The calyx is monophyllous; there is no corolla; the capsula is unilocular, quinquevalved, and pentaspermous. There is one species.

GLAZIER, an artificer who works in glass. The principal part of a glazier's business consists in fitting panes of glass to the sashes and window-frames of houses, pictures, &c. and in cleaning the same when required.

GLAZIER's VICE, is an instrument for drawing lead: see Plate LXVI. Miscel. fig. 102. PG, QH, are two axles running in the frame KL, ML; C, D, two wheels of iron case-hardened, $1\frac{1}{2}$ inch broad, and of the thickness of a pane of glass; these wheels are fixed to the axles, and run very near one another, their distance not exceeding one-tenth of an inch: across their edges several nicks are cut, the better to draw the lead through. E, F, are two pinions, each of twelve leaves, turning one another and going upon the ends of the axles, which are square, being kept fast there by the nuts P, Q, which are screwed fast with a key. A, B, are two cheeks of iron, case-hardened, and fixed on each side to the case with screws; these are cut with an opening near the two wheels, and set so near to the wheels as to leave a space equal to the thickness of the lead; so that between the wheels and the cheeks there is left a hole of the form represented at N, which is the shape of the lead when cut through. The frame KLML is held together by cross bars passing through the sides, and screwed on; and a cover is put over the machine to exclude the dust. The whole is screwed down fast to a bench by screw-nails LL. When the vice is used, the lead to be drawn is first cast in moulds, into pieces a foot long, with a gutter on each side. One of these pieces is taken, and an end of it sharpened with a knife; then being put into the hole between the wheels, by turning the handle I the lead is drawn through the vice, and receives the form designed.

GLAZING, the crusting over earthen-ware by a vitreous substance, the basis of which is commonly lead. The usual composition for glazing ware is formed of white sand 40 pounds, of red-lead 20 pounds, of pearl-ashes 20 pounds, and of common salt 12 pounds. Powder the sand by grinding it, and then add it to the other ingredients, and grind them together; after which calcine them for some time with a moderate heat, and when the mixture is cold, reduce it to powder, and when wanted for use temper it with water. The proportion of these ingredients may be occasionally varied. The ware, after being turned on the wheel and dried in the open air, is covered over with the above composition by means of a brush; and when set in the furnace, the violent heat soon reduces it to a perfect glass, covering the whole internal and external surface of the vessel. We may observe, however, that lead, being poisonous, ought to be excluded from the composition of glazings, and other fluxes substituted in its stead. A transparent glazing may be prepared without lead by calcining 40 pounds of white sand, 25 pounds of pearl-ashes, and 15 pounds of common salt, and proceeding as before: and a more perfect transparent glazing may be made of sand 40 pounds, of

wood-ashes perfectly burned 50 pounds, of pearl-ashes 10 pounds, and of common salt 12 pounds. The following receipts are taken for the most part from Kunckel, who says that they are the true glazings used at Delft and other Dutch manufactories.

Black is made of eight parts of red-lead, iron-filings three, copper-ashes three, and zaffer two measures. This when melted will make a brown-black, and if wanted blacker, add more zaffer to it.

Blue is thus prepared: Take lead-ashes or red-lead one pound; clear sand or powdered flints two pounds, common salt two pounds, white calcined tartar one pound, Venice or other glass half a pound, zaffer half a pound; mix them and melt them for several times, quenching them always in cold water. If you would have it fine and good, it will be proper to put the mixture into a glass furnace for a day or two. Another blue glazing may be formed of one pound of tartar, a quarter of a pound of red-lead, half an ounce of zaffer, and a quarter of a pound of powdered flints, which are to be fused and managed as in the last receipt. Or, take two pounds of calcined lead and tin, add five pounds of common salt, five pounds of powdered flints, and of zaffer, tartar, and Venetian glass, each one pound. Calcine and fuse the mixture as before. Or again, take of red-lead one part, of sand three parts, and of zaffer one part. For a violet-blue glazing, take four ounces of tartar, two ounces of red-lead, five ounces of powdered flints, and half a dram of manganese.

Brown is made of red-lead and flints, of each 14 parts, and of manganese two parts fused, or of red-lead 12 parts, and manganese one part fused. A brown glazing, to be laid on a white ground, may be made of manganese two parts, and of red-lead and white glass, of each one part, twice fused.

Flesh-coloured is made of 12 parts of lead-ashes, and one of white glass.

Gold-coloured. Take of litharge three parts, of sand or calcined flint one part; pound and mix these very well together, then run them into a yellow glass with a strong fire. Pound this glass, and grind it into a subtile powder, which moisten with a well-saturated solution of silver; make it into a paste, which put into a crucible, and cover it with a cover. Give at first a gentle degree of fire; then increase it, and continue it till you have a glass, which will be green. Pound this glass again, and grind it to a fine powder; moisten this powder with some beer, so that by means of a hair-pencil you may apply it upon the vessels or any piece of earthenware. The vessels that are painted or covered over with this glazing must be first well heated, then put under a muffle; and as soon as the glass runs, you must smoke them by holding them over burning vegetables, and take out the vessels.

Kunckel gives several preparations for a gold-coloured yellow glazing. This may be produced by fusing a mixture of three parts of red-lead, two parts of antimony, and one part of saffron of Mars; by again melting the powdered mass, and repeating the operation four times, or by fusing four or five times a composition of red-lead and antimony, of each an ounce, and of scales of iron half an ounce; or by calcining and fusing together eight parts of red-lead, six parts of flint, one part of yellow ochre, one part of antimony, and one part of white glass. A transparent gold-coloured glazing may be obtained by twice fusing red-lead and white flints, of each 12 parts, and of filings of iron one part.

Green may be prepared of eight parts of litharge or red-lead, eight parts of Venice glass, four parts of brass-dust or filings of copper; or of ten parts of litharge, twelve of flint or pebble, and one of æs ustum or copper ashes. A fine green glazing may be produced by fusing one part of the Bohemian granite, one of filings of copper, one of red-lead, and one of Venetian glass; or by fusing one part of white glass, the same quantity of red-lead, and also of filings of copper; powdering the mass, and adding one part of Bohemian granite to two parts of this powder. A fine green may be obtained by mixing and grinding together any of the yellow glazings with equal quantities of the blue glazings; and all the shades and tints of green will be had by varying the proportion of the one to the other, and by the choice of the kind of yellow and blue.

Sea-green is made of five pounds of lead-ashes, one pound of tin-ashes, three pounds of flint, three quarters of a pound of salt, half a pound of tartar, and half a pound of copper-dust.

Iron-colour is prepared of 15 parts of lead ashes or red-lead, 14 of white sand or flints, and five of calcined copper. This mixture is to be calcined and fused.

Liver-colour is prepared of 12 parts of litharge, eight of salt, six of pebble or flint, and one of manganese.

Purple brown consists of lead-ashes 15 parts, clean sand or powdered flints 18 parts, manganese one part, and white glass 15 measures, to which some add one measure of zaffer.

Red is made of antimony three pounds, litharge or red-lead three, and rust of iron one; grind them to a fine powder. Or, take two pounds of antimony, three of red-lead, and one of calcined saffron of Mars, and proceed as before.

White. The white glazing for common ware is made of 40 pounds of clear sand, 75 pounds of litharge or lead-ashes, 26 of pot-ashes, and 10 pounds of salt; these are three times melted in a cake, quenching it each time in clear cold water. Or it may be made of 50 pounds of clean sand, 70 of lead-ashes, 30 of wood-ashes, and 12 of salt. For a fine white, take two pounds of lead and one of tin; calcine them to ashes: of this take two parts; calcined flint, white sand, or broken white glass, one part; and salt, one part; mix them well together, and melt them into a cake for use. The trouble of calcining the tin and lead may be prevented by procuring them in a proper state. A very fine white glazing may be obtained by calcining two parts of lead and one part of tin, and taking one part of this mass, and of flints and common salt of each one part, and fusing the mixture. A white glazing may be also prepared by mixing 100 pounds of masticot, 60 of red-lead, 20 of calcined tin or putty, and 10 of common salt, and calcining and powdering the mixture several times.

Yellow is prepared of red-lead three pounds, calcined antimony and tin of each two pounds; or, according to some, of equal quantities of the three ingredients. These must be melted into a cake, then ground fine, and this operation repeated several times; or it may be made of 15 parts of lead-ore, three parts of litharge of silver, and 15 parts of sand. A fine yellow glazing may be procured by mixing five parts of red-lead, two parts of powdered

brick, one part of sand, one part of the white glazings, and two parts of antimony, calcining the mixture and then fusing it. Or, take four parts of white glass, one part of antimony, three parts of red-lead, and one part of iron-scales, and fuse the mixture; or fuse 16 parts of flints, one part of iron-filings, and 24 parts of litharge. A light-yellow glazing may be produced with ten parts of red-lead, three parts of antimony, and three of glass, and two parts of calcined tin (see gold colour above). A citron yellow is made of six parts of red-lead, seven parts of fine red brickdust, and two parts of antimony. This mixture must be calcined day and night for the space of four days, in the ash-hole of a glass-house furnace, and at last urged to fusion. See STONE WARE.

GLEANING. It has been said, that by the common law and custom of England the poor are allowed to enter and glean upon another's ground after the harvest, without being guilty of trespass; and this humane provision seems borrowed from the Mosaical law. 3 Black. 212.

But it is now positively settled, by a solemn judgment of the court of common pleas, that a right to glean in the harvest-field cannot be claimed by any person at common law; neither have the poor of a parish, legally settled, such a right. 1 H. Black. Rep. 51—63.

GLEBE. Glebe land is a portion of land, meadow, or pasture, belonging to, or parcel of, the parsonage or vicarage, over and above the tithes. Godolph. Rep. 409.

Glebe lands, in the hands of the parson, shall not pay tithes to the vicar, nor being in the hands of the vicar, shall they pay tithe to the parson. Deggs, Pars. Couns. c. 2.

By stat. 28 H. VIII. c. 11, every successor on a month's warning, after induction, shall have the mansion-house and the glebe belonging thereto, not sown at the time of the predecessor's death. He that is instituted may enter into the glebe land before induction, and plead right against all strangers.

When a parson or vicar has caused any of his glebe lands to be manured and sown, at his own charge, with corn or grain, he may by will devise all the profits and corn growing upon the said glebe; and in case he dies without disposing thereof, his executors shall have the same.

GLECHOMA, *ground-ivy*, a genus of the gymnospermia order, in the didynamia class of plants, and in the natural method ranking under the 42d order, verticillatæ. Each pair of the antheræ come together in the form of a cross; the calyx is quinquefid. There is one species, the hederacea, or common ground-ivy, which is so well known that it requires no description. Many virtues were formerly attributed to this plant, which it is now found not to be possessed of. Some however it has. The leaves are thrown into the vat with ale, to clarify it and give it a flavour. Ale thus prepared is often drunk as an antiscorbutic. The expressed juice, mixed with a little wine, and applied morning and evening, is said to destroy specks upon horses' eyes. The plants that grow near it do not flourish. It is said to be hurtful to horses if they eat much of it. Sheep eat it; horses are not fond of it; cows, goats, and swine, refuse it.

GLEDITSIA, *triple-thorned acacia*, or *honey-locust*, a genus of the diœcia order, in the polygamia class of plants, and in the natural method ranking under the 33d order, lomentaceæ. The hermaphrodite calyx is quadrifid, the corolla tetrapetalous, the stamina six, one pistil and legumen. The male calyx is triphyllous; the corolla tripetalous, with six stamina. The female calyx is pentaphyllous; the corolla pentapetalous, one pistil and legumen.

There is one species. The triacanthos, a native of Virginia and Pennsylvania, is of an upright growth, and its trunk is guarded by thorns of three or four inches in length in a remarkable manner. These thorns have also others coming out of their sides at nearly right angles: their colour is red. The branches are smooth, and of a white colour. These are likewise armed with red thorns, that are proportionably smaller: they are of several directions, and at the ends of the branches often stand single. The young shoots of the preceding summer are perfectly smooth, of a reddish green, and retain their leaves often until the middle of November. Although there is a peculiar oddity in the nature and position of the spines, yet the leaves constitute the greatest beauty of these trees: they are doubly pinnated, and of a delightful shining green. The pinnated leaves that form the duplication do not always stand opposite by pairs on the middle rib; the pinnæ of which they are composed are small and numerous, no less than 10 or 11 pair belong to each of them; and as no less than four or five pair of small leaves are arranged along the middle rib, the whole compound leaf consists often of more than 200 pinnæ of this fine green colour. They sit close, and spread open in fine weather; though during bad weather they will droop, and their upper surfaces nearly join, as if in a sleeping state. The flowers are produced from the sides of the young branches in July: they are a greenish catkin, and make little show; though many are succeeded by pods that have a wonderful effect; for these are exceedingly large, more than a foot, sometimes a foot and a half in length, and two inches in breadth, and of a nut-brown colour when ripe, so that the effect, when hanging on the sides of the branches, may easily be imagined. The seed should be sown in a well-sheltered warm border of light sandy earth. If no border is to be found that is naturally so, it may be improved by applying drift sand, and making it fine. The seeds should be sown about half an inch deep, and they will for the most part come up the first spring. If the summer should prove dry, they must be constantly watered; and if shade could be afforded them in the heat of the day, they would make stronger plants by the autumn. A careful attention to this article is peculiarly requisite; for, as the ends of the branches are often killed, if the young plant has not made some progress, it will be liable to be wholly destroyed by the winter's frost, without protection: and this renders the sowing the seeds in a warm border under a hedge in a well-sheltered place necessary; for there these shrubs will endure the winters even when seedlings, and so will require no farther trouble; nay, though the tops should be nipped, they will shoot out again lower, and will soon overcome it. It will be proper to let them remain two years in the seed-bed before they are planted out in the nursery. The spring is the best time for the work. These trees are late in the spring before

they exhibit their leaves, but keep shooting long in the autumn.

GLINUS, a genus of the pentagynia order, in the decandria class of plants, and in the natural method ranking under the 22d order, caryophyllæi. The calyx is pentaphyllous; there is no corolla; the nectarium is composed of bifid bristles; the capsule is quinquangular, quinquelocular, quinquevalved, and polyspermous. There are three species, herbs of Arabia and the south of Europe.

GLIRES, the name given by Linnæus to the fourth order of the mammalia, the character of which is, foreteeth cutting, two in each jaw; no tusks; feet with claws formed for running and bounding; food, bark, roots, vegetables, &c. which they gnaw. The order includes ten genera, viz. the hystrix, cavia, castor, mus, arctomys, sciurus, myoxus, dipus, lepus, and hyrax.

GLISTER, in surgery, the same with clyster.

GLOBBA, a genus of the monogynia order, in the monandria class of plants. The corolla is equal and trifid, the calyx trifid above, the capsule trilocular, with many seeds. There are four species, herbs of the East Indies.

GLOBE, in geometry, a round or spherical body, more usually called a sphere. See Sphere.

Globe is more particularly used for an artificial sphere of metal, plaister, paper, or other matter, on whose convex surface is drawn a map or representation either of the earth or heavens, with the several circles conceived thereon.

Globes are of two kinds, terrestrial and celestial; each of very considerable use, the one in astronomy, and the other in geography, for performing many of the operations in an easy obvious manner, so as to be conceived without any knowledge of the mathematical grounds of those arts. The fundamental parts, common to both globes, are an axis, representing that of the world, and a spherical shell or cover; which makes the body of the globe, on the external surface of which the representation is drawn.

The globes commonly used are composed of plaister and paper in the following manner. A wooden axis is provided, somewhat less than the intended diameter of the globe, and into the extremes two iron wires are driven for poles: this axis is to be the beam or basis of the whole structure. On the axis are applied two spherical or rather hemispherical caps, formed on a kind of wooden mould or block. These caps consist of pasteboard or paper,l aid one lay after another on the mould, to the thickness of a crown-piece; after which, having stood to dry and embody, making an incision along the middle, the two caps thus parted are slipped off the mould. They remain now to be applied on the poles of the axis, as before they were on those of the mould; and to fix them in their new place, the two edges are sewed together with packthread, &c.

The rudiments of the globe thus laid, they proceed to strengthen and make it smooth and regular. In order to this, the two poles are hasped in a metalline semicircle of the size intended; and a kind of plaister made of whiting, water, and glue, heated, melted, and incorporated together, is daubed all over the paper surface. In proportion as the plaster is applied, the ball is turned round in the semicircle, the edge of which pares off whatever is superfluous, and beyond the due dimension, leaving the rest adhering in places that are short of it. After such application of plaister, the ball stands to dry; which done it is put again in the semicircle, and fresh matter applied: thus they continue alternately to apply the composition and dry it, till the ball every where accurately touches the semicircle; in which state it is perfectly smooth, regular, and complete.

The ball thus finished, it remains to paste the map or description on it. In order to this, the map is projected in several gores or gussets, all which join accurately on the spherical surface, and cover the whole ball. To direct the application of these gores, lines are drawn by a semicircle on the surface of the ball, dividing it into a number of equal parts corresponding to those of the gores, and sub-dividing those again answerably to the lines and divisions of the gores.

The papers thus pasted on, there remains nothing but to colour and illuminate the globe, and to varnish it, the better to resist dust, moisture, &c. The globe itself thus finished, they hang it in a brass meridian, with an hour-circle and a quadrant of altitude, and thus fit it into a wooden horizon.

GLOBES, *use of.* By the assistance of the globes a great number of curious, useful, and entertaining problems are worked, some of which we shall proceed to describe. The globe consists of several parts: as (1) the two poles, being the ends of the axis on which the globe turns, representing the diurnal motion of the earth, and the apparent diurnal motion of the heavens. (2) The brazen meridian, on which are marked the degrees from the equator to the poles. (3) The wooden horizon or frame that supports the whole globe, on which are drawn several circles, as that on which the signs of the zodiac are marked; that containing the calendar or days of the month which correspond to the several degrees of the zodiac; and that on which are delineated the 32 points of the compass. (4) The hour-circle, divided into twice 12 hours, representing the division of time for the day and the night. And, (5) a thin slip of brass, called the quadrant of altitude, useful in several problems to measure the distances and directions of the places from each other.

There are ten principal circles represented upon globes, viz. six greater and four lesser ones. The greater circles are, the brazen meridian, already described; the equinoctial, as it is called on the celestial, and equator on the terrestrial globe; the ecliptic drawn along the middle of the zodiac; and the two colures. The lesser circles, of principal use, are the two tropics and the two polar circles. Of these circles some are fixed, and always obtain the same position; others moveable, according to the position of the observer. The fixed circles are the equator and ecliptic, with their parallels and secondaries; which are usually delineated upon the surface of the globes. The moveable circles are the horizon, with its parallels and secondaries.

The horizon is that great and broad wooden circle surrounding the globe, and dividing it into two equal parts, called the upper and lower hemispheres. It has two notches, to let the brazen meridian slip up and down, according to the different heights of the pole. On the flat

side of this circle are described the twelve signs, the months of the year, the points of the compass, &c. The brazen meridian is an annulus or ring of brass, divided into degrees. It divides the globe into two equal parts, called the eastern and western hemispheres. The quadrant of altitude is a thin pliable plate of brass, answering exactly to a quadrant of the meridian. It is divided into 90°, and has a notch, nut and screw, to fix to the brazen meridian in the zenith of any place, where it turns round a pivot, and supplies the room of vertical circles. The hour-circle is a flat ring of brass, divided into 24 equal parts or hour-distances; and on the pole of the globe is fixed an index that turns round with the globe, and points out the hours upon the hour-circle. Lastly, there are generally added a compass and needle upon the pediment of the frame.

The surface of the celestial globe may be esteemed a just representation of the concave expanse of the heavens, notwithstanding its convexity; for it is easy to conceive the eye placed in the centre of the globe, and viewing the stars on its surface, supposing it made of glass, as some globes are: also that if holes were made in the centre of each star, the eye in the centre of the globe, properly placed, would view through each of the holes the very stars in the heavens represented by them.

As it would be impossible to have any distinct notion of the stars, in respect to their number, order, and distances, without arranging them in certain forms, called constellations, this the first observers of the heavens took care to do; and these, like kingdoms and countries upon the terrestrial globe, serve to distinguish the different parts of the superficies of the celestial globe. The stars, therefore, are all disposed in constellations under the forms of various animals, whose names and figures are represented on the celestial globe, which were first invented by the ancient astronomers and poets, and are still retained for the better distinction of these luminaries.

PROBLEMS ON THE CELESTIAL GLOBE.

1. *To rectify the globe:* that is, to place it in such a particular situation as is necessary for the solution of many problems. Raise or elevate the pole to the latitude of the place; screw the quadrant of altitude in the zenith; set the index of the hour-circle to the upper xii, and place the globe north and south by the compass and needle; then it is a just representation of the heavens for the given day at noon.

2. *To find the sun's place in the ecliptic.* Find the day of the month in the calendar on the horizon, and right against it is the degree of the ecliptic which the sun is in for that day.

3. *To find the sun's declination.* Rectify the globe, bring the sun's place in the ecliptic to the meridian, and that degree which it cuts in the meridian is the declination required.

4. *To find the sun's right ascension.* Bring the sun's place to the meridian, and the degree of the equinoctial cut by the meridian is the right ascension required.

5. *To find the sun's amplitude.* Bring the sun's place to the horizon, and the arch of the horizon intercepted between it and the east or west point, is the amplitude, north or south.

6. *To find the sun's amplitude for any given day and hour.* Bring the sun's place to the meridian, set the hour-index to the upper xii; then turn the globe till the index points to the given hour, where let it stand; then screwing the quadrant of altitude in the zenith, lay it over the sun's place, and the arch contained between it and the horizon will give the degrees of altitude required.

7. *To find the sun's azimuth for any hour of the day.* Every thing being done as in the last problem, the arch of the horizon contained between the north point and that where the quadrant of altitude cuts it, is the azimuth east or west as required.

8. *To find the time when the sun rises or sets.* Find the sun's place for the given day, bring it to the meridian, and set the hour hand to XII; then turn the globe till the sun's place touches the east part of the horizon, the index will show the hour of its rising; after that, turn the globe to the west part of the horizon, and the index will show the time of its setting for the given day.

9. *To find the length of any given day or night.* This is easily known by taking the number of hours between the rising and setting of the sun for the length of the day; and the residue to 24, for the length of the night.

10. *To find the hour of the day, having the sun's altitude given.* Bring the sun's place to the meridian, and set the hour-hand to XII; then turn the globe in such a manner, that the sun's place may move along by the quadrant of altitude (fixed in the zenith) till it touches the degree of the given altitude, where stop it, and the index will show on the horary circle the hour required.

11. *To find the place of the moon, or any planet, for any given day.* Take White's Ephemeris, Nautical Almanac, and against the given day of the month you will find the degree and minute of the sign which the moon or planet possesses at noon, under the title of geocentric motions. The degree thus found being marked in the ecliptic on the globe by a small notch or otherwise, you may then proceed to find the declination, right ascension, latitude, longitude, altitude, azimuth, rising, southing, setting, &c. in the same manner as has been shown for the sun.

12. *To explain the phænomena of the harvest moon.* In order to this we need only consider, that when the sun is in the beginning of Aries, the full moon on that day must be in the beginning of Libra: and since, when the sun sets or moon rises on that day, those equinoctial points will be in the horizon, and the ecliptic will then be least of all inclined thereto, the part or arch which the moon describes in one day, viz. 13°, will take up about an hour and a quarter ascending above the horizon; and, therefore, so long will be the time after sun-set, the next night, before the moon will rise. But at the opposite time of the year, when the sun is in the autumnal and the full moon in the vernal, equinox, the ecliptic will, when the sun is setting, have the greatest inclination to the horizon; and, therefore, 13° will in this case soon ascend, viz in about a quarter of an hour; and so long after sunset will the moon rise the next day after the full: whence at this time of the year, there is much more moonlight than in the spring; and hence this autumnal full moon came to be called the harvest moon, the hunter's or shepherd's moon; all which may be clearly shown on the globe.

13. *To represent the face of the starry firmament for any given hour of the night.* Rectify the globe, and turn it about till the index points to the given hour; then will all the upper hemisphere of the globe represent the visible half of the heavens, and all the stars on the globe will be in such situations as to correspond to those in the heavens, which may therefore be easily found, as will be shown in the 16th problem.

14. *To find the hour when any known star will rise, or come upon the meridian.* Rectify the globe, and set the index to XII; then turn the globe till the star comes to the horizon or meridian, and the index will show the hour required.

15. *To find at what time of the year any given star will be on the meridian at* XII *at night.* Bring the star to the meridian, and observe what degree of the ecliptic is on the north meridian under the horizon; then find in the calendar on the horizon the day of the year against that degree, and it will be the day required.

16. *To find any particular star.* First find its altitude in the heavens by a quadrant, and the point of the compass it bears on; then, the globe being rectified, and the index turned to the given hour, if the quadrant of altitude is fixed on the zenith, and laid towards the point of the compass on which the star was observed, the star required will be found at the same degree of altitude on the said quadrant, as it was by observation in the heavens.

PROBLEMS ON THE TERRESTRIAL GLOBE.

1. *To find the latitude of any place.* Bring the given place to the brazen meridian, and observe what degree it is under, for that is the latitude required.

2. *To rectify the globe for any given place.* Raise the pole so many degress above the horizon as are equal to the latitude of the place; then, finding the sun's place, bring it to the meridian, and proceed as directed in problem 1. on the celestial globe.

3. *To find the longitude of a given place.* Bring the place to the brazen meridian, and observe the degree of the equator under the same, for that expresses the longitude required.

4. *To find any place by the latitude and longitude given.* Bring the given degree of longitude to the meridian, and under the given degree of latitude you will see the place required.

5. *To find all those places which have the same latitude or longitude with those of any given place.* Bring the given place to the meridian; then all those places which lie under the meridian have the same longitude: again, turn the globe round on its axis; then all those places which pass under the same degree of the meridian with any given place have the same latitude with it.

6. *To find all those places where it is noon at any given hour of the day in any place.* Bring the given place to the meridian, set the index to the given hour; then turn the globe till the said index points to the upper XII, and observe what places lie under the brass meridian; for to them it is noon at that time.

7. *When it is noon at any one place, to find what hour it is at any other given place.* Bring the first given place to the meridian, and set the index to the upper XII; then turn the globe till the other given place comes to the meridian, and the index will point to the hour required.

8. *For any given hour of the day in the place where you are, to find the hour of the day in any other place.* Bring the place where you are to the meridian, set the index to the given hour, then turn the globe about; and when the other place comes to the meridian, the index will show the hour of the day there as required.

9. *To find the distance between any two places in English miles.* Bring one place to the meridian, over which fix the quadrant of altitude; and then laying it over the other place, count the number of degrees thereon contained between them; which number multiply by 69½ (the number of miles in one degree), and the product is the number of English miles required.

10. *To find how any one place bears from another.* Bring one place to the brass meridian, and lay the quadrant of altitude over the other, and it will show on the horizon the point of the compass on which the latter bears from the former.

11. *To find those places to which the sun is vertical in the torrid zone for any given day.* Find the sun's place in the ecliptic for the given time, and bring it to the meridian, and observe what degree thereof it cuts; then turn the globe about, and all those places which pass under that degree of the meridian, are those required.

12. *To find what day of the year the sun will be vertical to any given place in the torrid zone.* Bring the given place to the meridian, and mark the degree over it; then turn the globe round, and observe the two points of the ecliptic which pass under that degree of the meridian: lastly, see on the wooden horizon on what days of the year the sun in those points of the ecliptic; for those are the days required.

13. *To find those places in the north frigid zone where the sun begins to shine constantly without setting, on any given day between the 21st of March and the 21st of June.* Find the sun's place in the ecliptic for the given day, bring it to the brazen meridian, and observe the degrees of declination; then all those places which are the same number of degrees distant from the pole are the places required to be found.

14. *To find on what day the sun begins to shine constantly without setting, on any given place in the north frigid zone, and how long.* Rectify the globe to the latitude of the place, and turning it about, observe what point of the ecliptic between Aris and Cancer, and also between Cancer and Libra, coincides with the north point of the horizon; then find, by the calendar on the horizon, what days the sun will enter those degrees of the ecliptic, and they will satisfy the problem.

15. *To find the place over which the sun is vertical on any given day and hour.* Find the sun's place, and bring it to the meridian, and mark the degree of declination for the given hour; then find those places which have the sun in the meridian at that moment; and among them that which passes under the degree of declination is the place desired.

16. *To find, for any given day and hour, those places wherein the sun is then rising and setting, or in the meridian; also those places which are enlightened, and those which are not.* Find the place to which the sun is vertical at the given time, and bring the same to the meridian, and elevate the pole to the latitude of the place; then all those places which are in the western semicircle of

the horizon have the sun rising, and those in the eastern semicircle see it setting; and to those under the meridian it is noon. Lastly, all places above the horizon are enlightened, and all below are in darkness or night.

17. *The day and hour of a solar or lunar eclipse being given, to find all those places in which the same will be visible.* Find the place to which the sun is vertical at the given instant, and elevate the globe to the latitude of the place; then in most of those places above the horizon will the sun be visible during his eclipse; and all those places below the horizon will see the moon pass through the shadow of the earth in her eclipse.

18. *The length of a degree being given, to find the number of miles in a great circle of the earth, and thence the diameter of the earth.* Admit that one degree contains $69\frac{1}{2}$ English statute miles; then multiply 360 (the number of degrees in a great circle) by $69\frac{1}{2}$, and the product will be 25020, the miles which measure the circumference of the earth. If this number be divided by 3.1416, the quotient will be $7963\frac{86}{100}$ miles for the diameter of the earth.

19. *The diameter of the earth being known, to find the surface in square miles, and its solidity in cubic miles.* Admit the diameter to be 7964 miles, then multiply the square of the diameter by 3.1416, and the product will be 199250205 very near, which are the square miles in the surface of the earth. Again, multiply the cube of the diameter by 0.5236, and the product 264466789170 will be the number of cubic miles in the whole globe of the earth.

20. *To express the velocity of the diurnal motion of the earth.* Since a place on the equator describes a circle of 25020 miles in 24 hours, it is evident, that the velocity with which it moves is at the rate of $1042\frac{1}{2}$ in one hour, or $17\frac{3}{10}$ miles per minute. The velocity in any parallel of latitude decreases in the proportion of the co-sine of the latitude to the radius. Thus for the latitude of London, 51° 30′, say,

As radius	10.000000
To the co-sine of lat. 51° 30′	9.794149
So is the velocity in the equator, $17\frac{3}{10}$′	1.232046
To the velocity of the city of London, $10\frac{8}{10}$′	1.032195

That is the city of London moves about the axis of the earth at the rate of $10\frac{8}{10}$ miles every minute of time.

GLOBULAR CHART, a name given to the representation of the surface, or of some part of the surface, of the terrestrial globe upon a plane, wherein the parallels of latitude are circles nearly concentric, the meridian curves bending towards the poles, and the rhomb-lines are also curves.

GLOBULAR SAILING. See SAILING.

GLOBULARIA, *globular blue daisy*, a genus of the monogynia order, in the tetrandria class of plants, and in the natural method ranking under the 48th order, aggregatæ. The common calyx is imbricated, the proper one tubulated inferior, the upper lip of the florets bipartite, the under one tripartite, the receptacle paleaceous. There are eight species, but one only is commonly to be met with in our gardens, viz. the vulgaris, or common blue daisy. It has broad thick radical leaves, three-parted at the ends, upright stalks from about six to ten or twelve inches high, with spear-shaped leaves, and the top crowned by a globular head of fine blue flowers, composed of many florets in one cup. It flowers in June, and makes a good appearance, but thrives best in a moist shady situation. It is propagated by parting the roots in September.

GLORIOSA, *superb lily*, a genus of the hexandria monogynia class of plants, the flower of which consists of six oblongo-lanceolated, undulated, and very long petals, reflex nearly to the base: the fruit is an oval pellucid capsule, containing three cells, and numerous globose seeds, disposed in a double series. There are two species, herbaceous plants of Guinea.

GLOSSOMA, a genus of the tetrandria monogynia class and order. The calyx is turbinate, four-toothed, superior; corolla four-petalled; antheras almost united with membranaceous scales at the end; stigmas four; drupe. There is one species, a shrub of Guiana.

GLOSSOPETALUM, a genus of the pentandria pentagynia class and order. The calyx is five toothed; petals five, with a strap at the tip of each berry. There are two species, trees of Guiana.

GLOSSOPETRA, in natural history, a genus of extraneous fossils, so called from their having been supposed the tongues of serpents turned to stone, though they are really the teeth of sharks, and are found in the mouths of those fishes, wherever taken. The several sizes of teeth of the same species and the several different species of sharks, furnish us with a vast variety of these fossile teeth. Their usual colours are black, bluish, whitish, yellowish, or brown. In shape they are commonly somewhat approaching to triangular; some are simple, and others have a smaller point on each side the larger one; many of them are quite straight, but they are frequently met with crooked, and bent in all the different directions, some inwards, some outwards, and some sideways: they are also of various sizes, the larger ones being four or five inches long, and the smaller less than a quarter of an inch. They are found with us in the strata of blue clay, and are very plentiful in the clay pits of Richmond, and some other places; but they are no where so common as in the island of Malta.

GLOTTIS. See ANATOMY.

GLOVE, a covering for the hand and wrist. Gloves, with respect to commerce, are distinguished into leathern, silk, thread, cotton, worsted, &c. Leathern gloves are made of chamois, kid, lamb, doe, elk, buff, &c. To throw the glove, was a practice or ceremony very usual among our forefathers, being the challenge whereby another was defied to single combat. It is still retained at the coronation of our kings, when the king's champion casts his glove in Westminster-hall. Favyn supposes the custom to have arisen from the Eastern nations, who, in all their sales and deliveries of lands, goods, &c. used to give the purchaser their glove by way of livery or investiture. To this effect he quotes Ruth iv. 7. where the Chaldee paraphrase calls *glove* what the common version renders by *shoe*. He adds, that the rabbins interpret by *glove* that passage in the cviiith Psalm, In Idumean extendam calceamentum meum, "Over Edom will I cast my shoe." Accordingly, among us, he who took up the glove declared thereby his acceptance of the challenge; and as a part of the ceremony, continues Favyn, took the glove off his own right hand and cast it upon the ground, to be taken up by the challenger. This had the force of a mutual engagement on each side,

to meet at the time and place which should be appointed by the king, parliament, or judges. The same author asserts, that the custom which once obtained of blessing gloves in the coronation of the kings of France, was a remain of the Eastern practice of giving possession with the glove, l. xvi. p. 1017, &c. Anciently it was prohibited the judges to wear gloves on the bench; and at present, in the stables of some princes, it is said to be unfafe going in without pulling off the gloves.

GLOW-WORM. See CICINDELA.

GLOXINIA, a genus of the didynamia angiospermia class and order. The calyx is superior, five-leaved; corolla bell-shaped, with the border oblique; filaments with the rudiment of a fifth inserted into the receptacle. There is one species, a herb of South America.

GLUCINA, a new earth, discovered in 1798, in the mountains of Siberia. According to the experiments of Vauquelin and Klaproth, we learn that

1. To obtain glucina pure, the beryl or emerald reduced to powder, is to be fused with thrice its weight of potass. The mass is to be diluted with water, dissolved in muriatic acid, and the solution evaporated to dryness. The residuum is to be mixed with a great quantity of water, and the whole thrown on a filtre. The silica, which constitutes more than half the weight of the stone, remains behind; but the glucina and the other earths, being combined with muriatic acid, remain in solution. Precipitate them by means of carbonat of potass. Wash the precipitate, and then dissolve it in sulphuric acid. Add to the solution sulphat of potass; evaporate it to the proper consistence, and set it by to crystallize. Alum crystals gradually form. When as many of these as possible have been obtained, pour in the liquid carbonat of ammonia to excess, then filtre, and boil the liquid for some time. A white powder gradually appears, which is glucina.

2. Glucina, thus obtained, is a soft light white powder, without either taste or smell, which has the property of adhering strongly to the tongue. It has no action on vegetable colours. It is altogether infusible by heat; neither does it harden or contract in its dimensions, as is the case with alumina. Its specific gravity is 2.967.

It is insoluble in water, but forms with a small quantity of that liquid a paste which has a certain degree of ductility.

3. It does not combine with oxygen nor any of the simple combustibles; but sulphurated hydrogen dissolves it, and forms with it a hydrosulphurat, similar to other hydrosulphurats in its properties.

4. Azote has no action on it; but muriatic acid dissolves it, and forms with it a sweet-tasted salt, called muriat of glucina.

5. Glucina is soluble in the liquid fixed alkalies, in which it agrees with alumina. It is insoluble in ammonia, but soluble in carbonat of ammonia, in which respect it agrees with yttria; but it is about five times more soluble in carbonat of ammonia than that earth.

It combines with all the acids, and forms with them sweet-tasted salts, as is the case also with yttria.

GLUE, among artificers, a tenacious viscid matter, which serves as a cement to bind or connect things together. See GELATINE.

GLUTA, a genus of the class and order pentandria monogynia. The calyx is bell-shaped, deciduous; petals five; filaments inserted into the tip of the column; germ sitting in an oblong column. There is one species, a tree of Java.

GLUTÆUS. See ANATOMY.

GLUTEN. If wheat flour is kneaded into paste with a little water, it forms a tenacious, elastic, soft, ductile mass. This is to be washed cautiously, by kneading it under a small jet of water till the water no longer carries off any thing, but runs off colourless; what remains behind is called gluten. It was discovered by Beccaria, an Italian philosopher, to whom we are indebted for the first analysis of wheat flour.

1. Gluten, when thus obtained, is of a grey colour, exceedingly tenacious, ductile, and elastic, and may be extended to twenty times its original length. When very thin, it is of a whitish colour, and has a good deal of resemblance to animal tendon or membrane. In this state it adheres very tenaciously to other bodies, and has often been used to cement together broken pieces of porcelain. Its smell is peculiar. It has scarcely any taste, and does not lose its tenacity in the mouth. When exposed to the air, it assumes a brown colour, and becomes in a manner covered with a coat of oil.

When exposed to the air, it gradually dries; and when completely dry, it is pretty hard, brittle, slightly transparent, of a dark-brown colour, and has some resemblance to glue. It breaks like a piece of glass, and the edges of the fracture resemble in smoothness those of broken glass; that is, it breaks with a vitreous fracture.

It is insoluble in water, though it imbibes and retains a certain quantity of it with great obstinacy. To this water it owes its elasticity and tenacity. When boiled in water it loses both these properties.

When kept moist, it very soon begins to decompose, and to undergo a species of fermentation. It swells, and emits air-bubbles, which Proust has ascertained to consist of hydrogen and carbonic acid gases. It emits also a very offensive odour, similar to what is emitted by putrefying animal bodies. Cadet kept gluten for a week in a damp room. Its surface became covered with byssi, the fermentation just mentioned had commenced, and the odour was distinctly acid. In 24 days, on removing the upper crust, the gluten was found converted into a kind of paste, of a greyish white colour, not unlike bird-lime. In that state he gave it the name of fermented gluten. If the gluten is still left to itself, it gradually acquires the smell and taste of cheese. This curious fact was first ascertained by Rouelle junior, to whom we are indebted for the most important dissertation on gluten which has yet appeared. In that state it is full of holes, and contains the very same juices which distinguish some kinds of cheese. Proust ascertained that it contains ammonia and vinegar; bodies which Vauquelin detected in cheese: and ammonia robs both equally of their smell and flavour.

When moist gluten is suddenly dried, it swells amazingly. Dry gluten, when exposed to heat, cracks, swells, melts, blackens, exhales a fetid odour, and burns precisely like feathers or horn. When distilled, there comes over water impregnated with ammonia and an empyreumatic oil; the charcoal which remains is with difficulty reduced to ashes.

2. Gluten is insoluble in water; it is equally insoluble

in alcohol and in ether. But when the fermented gluten of Cadet is triturated with a little alcohol into a mucilage, and then mixed with a sufficient quantity of that liquid, a portion of it is dissolved. This solution constitutes an excellent varnish, possessed of considerable elasticity. It may be spread over paper or wood; and when dry resists other bodies as well as most varnishes. In this state too it may be employed to cement china; and triturated with paints, especially vegetable colours, it forms a very good ground. When this solution is mixed with a sufficient quantity of lime, it forms a very good lute; and bits of linen dipt in it adhere very strongly to other bodies.

All the acids dissolve it, even when very much diluted; alkalies precipitate it again, but it is deprived of its elasticity, and brought nearer to the state of extractive matter. Concentrated sulphuric acid renders it violet-coloured, and at last black; inflammable air escapes, and charcoal, water, and a portion of ammonia, are formed. When nitric acid is poured on it, and heat applied, there is a quantity of azotic gas emitted, as Berthollet discovered; and by continuing the heat, some little oxalic acid is formed, and likewise malic acid, while a number of yellow-coloured oily flakes make their appearance in the solution. Acetic acid acts but imperfectly, but it dissolves the fermented gluten of Cadet; and the solution may be substituted for the solution in alcohol as a varnish; but it does not answer to mix it with colours.

Alkalies dissolve gluten when they are assisted by heat. The solution is never perfectly transparent. Acids precipitate the gluten from alkalies, but it is destitute of its elasticity. Alkalies, when much concentrated, form with it a kind of soap, converting it into oil and ammonia, which last is dissipated during the trituration.

The action of the metallic oxides and their salts upon gluten has not been tried.

It has a strong affinity for the colouring matter of vegetables, and likewise for resinous bodies.

3. The properties of this substance clearly point out a resemblance between it and animal matter; and the phenomena of its fermentation and destructive distillation show us that oxygen, hydrogen, carbon, and azote, are constituents of it. Proust has observed, that the vapour which it emits, while fermenting, blackens silver and lead, and of course contains sulphur.

4. Like all other vegetable principles, gluten is susceptible of various shades of properties, which constitute so many species. In wheat flour, it occurs in the greatest abundance, and from it we can extract it with the greatest ease. But the sagacity and industry of Rouelle and Proust have detected its presence in many other vegetable substances. Rouelle found it in the leaves of all the vegetable substances which he examined. The exactness of this opinion was called in question by Fourcroy, who treated the experiments of Rouelle with contempt; but it has been lately examined and confirmed by very decisive experiments of Proust.

When the juice of cabbage-leaves, cresses, scurvy-grass, and other similar plants, is extracted by pressure, and passed through a cloth, it still continues far from transparent. Its muddiness is owing to a fine soft silky green powder suspended in it, which subsides to the bottom so slowly as to take at least a week before it is deposited. This green powder has been distinguished by the name of the green fecula of plants. Rouelle first examined it with attention, and ascertained its properties; and the subject has been carried still farther by Proust. The slowness with which it subsides shows that its specific gravity does not differ much from that of water. When once it has fallen, it is insoluble. This substance consists chiefly of three principles: 1. A green matter to which it owes its colour, separated by digestion in alcohol, and which possesses the properties of a resin. 2. A substance which consists chiefly of woody fibres, and which is left behind when the fecula is digested in potass. 3. A species of gluten, which constitutes the greatest part of it, and to which it owes its characteristic properties.

When the juice of the plants is exposed to a heat of about 130°, the green fecula undergoes a kind of coagulation, concreting into large flakes, which subside very quickly. At this temperature, albumen is not altered by heat. This is the method commonly taken to clarify these juices. We see from it, that the fecula was united to the water by a very small force, which the addition of heat weakened sufficiently to enable the gluten to cohere. This coagulation by heat takes place how diluted soever the juices are with water, which is by no means the case with albumen. It is thrown down also by the addition of a little alcohol, by all acids, by ammonia, by sulphurated hydrogen gas, or by throwing into the liquid crystals of carbonat of potass, magnesia, common salt, muriat of potass, nitre, sal ammoniac, &c.

When separated from water, it soon dries, and becomes elastic, and has somewhat of the appearance of horn; and in that state is scarcely softened by hot water. When treated like gluten, it gradually acquires the cheesy taste and smell. When kept under water, it very soon begins to putrefy, and exhales a gas which blackens silver and solutions of lead. This speedy putrefaction in stagnant water takes place when flax and hemp are steeped. These substances contain green fecula in their rind, and the putrefaction occasions the separation of the whole, which could not otherwise be accomplished. The water which has been allowed to remain for a whole year over green fecula, contains sulphurated hydrogen, carbonat of ammonia, and gluten seemingly held in solution by the ammonia. The stench of putrefaction still continues even after the water has been boiled.

5. The number of plants containing gluten is very considerable. Proust found it in acorns, chesnuts, horse-chesnuts, rue, barley, rye, peas, and beans; and in apples and quinces. He found it also in the leaves of cabbage, sedums, cress, hemlock, borage, saffron, &c.; in the berries of the elder, the grape, &c.; in the petals of the rose, &c. It occurs also in several roots. Proust could find none in the potatoe.

6. Gluten must be considered as one of the most useful of the vegetable principles. It constitutes an essential ingredient in wheat, and is the substance which renders flour of wheat so fit for forming bread. It seems also to constitute the essential part of yeast. Its uses as a varnish, a ground for paint, &c. pointed out by Cadet, likewise deserve attention. The gluten of wheat is said, in many cases at least, to constitute the base of the substance called bird-lime; though that substance is supposed to be a preparation obtained from the bark of the

elm, &c. and in that case is, according to Proust, a kind of turpentine or resin, soluble in alcohol, and not in the least resembling gluten.

GLYCONIAN VERSE, in ancient poetry, consists of three feet, whereof the first is a spondee, the second a choriambus, and the last a pyrrhichius; or the first may be a spondee, and the other two dactyls.

Thus, *Mens re-* | *gnum bona pos-* | *sidet-*
or, *Mens re-* | *gnum bona* | *possidet.*

GLYCINE, *knobbed-rooted liquorice-vetch*, a genus of the decandria order, in the diadelphia class of plants, and in the natural method ranking under the 32d order, papilionaceæ. The calyx is bilabiate; the carina of the corolla turning back the vexillum with its point. There are 25 species, one of which is commonly cultivated in our gardens, the frutescens, or Carolina kidney-bean tree. This has shrubby climbing stalks, twining round any support, 15 or 20 feet high, adorned with pinnated leaves of three pair of follicles terminated by an odd one, and from the axillas clusters of large bluish purple flowers, succeeded by long pods like those of the climbing kidney-bean. It flowers in June and July. It is easily propagated, either by seeds or by layers.

The glycino coccinea is an elegant little plant, lately introduced into our stoves, and easily propagated by seed.

GLYCIRRHIZA, *liquorice*, a genus of the decandria order, in the diadelphia class of plants, and in the natural method ranking under the 32d order, papilionaceæ. The calyx is bilabiate; the upper lip tripartite, and the under one entire; the legumen ovate and compressed. There are four species. The glabra, or common liquorice, has a long, thick, creeping root, striking several feet deep into the ground; upright, firm, herbaceous stalks annually, three or four feet high, with winged leaves of four or five pair of oval lobes, terminated by an odd one; and from the axillas erect spikes of pale-blue flowers, which appear in July, succeeded by short smooth pods. The root of this is the useful part, which is replete with a sweet, balsamic, pectoral juice, much used in all compositions for coughs and disorders of the stomach. The echinata, or prickly-podded liquorice, is nearly like the common sort, only the seed-pods are prickly. Both these species are very hardy perennials; but the first is the sort commonly cultivated for use, its roots being fuller of juice and sweeter than the other. The roots are perennial; but the stalks rise in spring and decay in autumn.

Their propagation is effected by cuttings of the small roots issuing from the sides of the main ones near the surface of the earth, dividing them into lengths of six or eight inches, each having one or more good buds or eyes; and the proper season for procuring the sets for planting is any time in open weather from October till March, though from the middle of February till the middle of March is rather the most successful season for planting. An open situation is the most suitable for a plantation of these plants. Particular regard should also be had to the soil; it ought to be of a light loose composition, and three or four feet deep if possible; for the roots of the liquorice will arrive at that depth and more, and the longer the roots the more valuable they are for sale by weight.

In three years after planting, the roots of the liquorice will be fit to take up; and the proper season for this is any time from the beginning of November till February; for it should neither be taken up before the stalks are fully decayed, nor deferred till late in the spring, otherwise the roots will be apt to shrivel, and diminish in weight. In taking them up, the small side-roots are trimmed off: and the best divided into lengths for fresh sets, and the main roots are tied in bundles ready for sale.

Liquorice is almost the only sweet that quenches thirst; whence it was called by the Greeks adipson. Galen takes notice, that it was employed in this intention in hydropic cases, to prevent the necessity of drinking. Mr. Fuller, in his Medicina Gymnastica, recommends this root as a very useful pectoral; an assertion warranted by experience. An extract is directed to be made from it in the shops; yet this preparation is chiefly brought from abroad, though the foreign extract is not the best.

GMELINA, a genus of the angiospermia order, in the didynamia class of plants, and in the natural method ranking under the 40th order, personatæ. The calyx is nearly quadridentated; the corolla campanulated or bell-shaped; there are two bipartite and two simple antheræ; the fruit is a plum with a bilocular kernel. There is one species, a tree of Malabar.

GNAPHALIUM, *cudweed, goldy locks, eternal flower*, &c. a genus of the polygamia superflua order, in the syngenesia class of plants, and in the natural method ranking under the 49th order, compositæ. The receptacle is naked; the pappus feathered; the calyx imbricated, with the marginal scales roundish, parched, and coloured. There are 66 species; the most remarkable of which are: 1. The margaritaceum, or pearly white eternal flower, has creeping, very spreading roots, crowned with broad spear-shaped, white, hoary leaves; herbaceous, thick, woolly stalks, a foot and a half high, branching outward, with long, acute pointed, white, woolly leaves, and terminated by a corymbose cluster of yellowish flowers, which appear in June and July, and are very ornamental. 2. The plantaginium has large woolly radical leaves, decumbent running roots, and herbaceous simple stalks, rising six or eight inches, terminated by a corymbus of white flowers, which appear in June, July, &c. 3. The stechas has a shrubby stalk, dividing into slender branches three feet long, terminated by corymbose clusters of yellow flowers, appearing in May and June. 4. The orientale has three varieties, with yellow, gold-coloured, and white silvery flowers. They have shrubby stalks, rising two or three feet high. 5. The odoratissimum, or sweet-scented eternal flower, has shrubby winged stalks, branching irregularly a yard high, with corymbose clusters of bright yellow flowers, changing to a dark yellow. 6. The arboreum, or tree gnaphalium, has a woody stem, branching four or five feet high, narrow sessile leaves, with revolute borders, smooth on their upper side, and roundish bunches of pale yellow flowers. The first three sorts are hardy, and will thrive in any soil or situation. The first two increase exceedingly by their roots; and the third is easily propagated by slips. The fourth, fifth, and sixth sorts are somewhat tender, and therefore should be kept in pots, to be sheltered in a green-house or garden-frame in winter. Others may be planted in the full ground, in a dry and warm situation, especially the oriental kind

and varieties, and likewise the sweet-scented kind; for these two species will struggle tolerably through an ordinary winter, and make a pretty appearance during the summer months. All these are propagated by slips or cuttings of their shoots. The flowers of all these species are remarkable for retaining their beauty for years, if carefully gathered in a dry day, soon after they are blown.

GNAT. See CULEX.

GNEISS, in mineralogy, is composed essentially of felspar, quartz, and mica, forming plates which are laid on each other, and separated by thin layers of mica. It differs from granite in being shistose. Gneiss rocks are usually stratified. Like granite, it sometimes contains shorl and garnet. The beds of gneiss sometimes alternate with layers of granular limestone, shistose, hornblende, and porphyry. It is rich in ores, almost every metal having been found in gneiss rocks, either in veins, or beds.

GNETUM, a genus of the monadelphia order, in the monœcia class of plants. The amentum of the male is a single scale; there is no corolla, and but one filament with a pair of antheræ. The calyx of the female is of the same form; there is no corolla; the style with the stigma is trifid; the fruit a monospermous plum. There is one species, a herb of the East Indies.

GNIDIA, a genus of the monogynia order, in the octandria class of plants. The calyx is funnel-shaped and quadrifid, with four petals inserted into it; there is one seed somewhat resembling a berry. There are 11 species, shrubs of the Cape.

GNOMON, in dialling, the style, pin, or cock of a dial, which by its shadow shows the hour of the day. The gnomon of every dial represents the axis of the world. See DIAL and DIALLING.

GNOMON, in geometry. If in a parallelogram A B C D (plate LXIV. Miscel. fig. 103.) the diameter A C be drawn; also two lines E F, H I, parallel to the sides of the parallelogram, and cutting the diameter in one and the same point G, so that the parallelogram is, by these parallels, divided into four parallelograms, then are the two parallelograms DG, BG, through which the diameter does not pass, called complements; those through which the diameter passes, EH, FI, are called the parallelograms about the diameter; and a gnomon consists of the two complements, and either of the parallelograms about the diameter, viz. GD+HE+EI, or GD+FI+GB.

GNOMON, in astronomy, a style erected perpendicular to the horizon, in order to find the altitude of the sun. Thus, in the right-angled triangle ABC, fig. 104. are given AB the length of the style, BC the length of its shadow, and the right angle ABC. Hence, making CB the radius, we have this analogy for finding the angle ACB, the sun's altitude, viz. BC : AB : : radius : tangent of the angle C. By means of a gnomon, the sun's meridian altitude, and consequently the latitude of the place, may be found more exactly than with the smaller quadrants. See QUADRANT.

By the same instrument the height of any object GH may be found; for as DF (fig. 105) the distance of the observer's eye from the gnomon, is to DE, the height of the style, so is FH, the distance of the observer's eye from the object, to GH its height.

The following example will serve to illustrate the above proposition. Pliny says, that at Rome, at the time of the equinoxes, the shadow is to the gnomon as 8 to 9; therefore as 8 : 9 : : 1 or radius : $\frac{9}{8} = 1{\cdot}125$ a tangent, to which answers the angle 48° 22′, which is the height of the equator at Rome, and its complement 41° 38′ is therefore the height of the pole, or the latitude of the place.

Riccioli remarks the following defects in the observations of the sun's height, made with the gnomon by the ancients, and some of the moderns, viz. that they neglected the sun's parallax, which makes his apparent altitude less, by the quantity of the parallax, than it would be if the gnomon were placed at the centre of the earth: 2d, they neglected also the refraction, by which the apparent height of the sun is a little increased: and 3dly, they made the calculations from the length of the shadow, as if it were terminated by a ray coming from the centre of the sun's disc; whereas the shadow is really terminated by a ray coming from the upper edge of the sun's disc; so that, instead of the height of the sun's centre, their calculations gave the height of the upper edge of his disc: and, therefore, to the altitude of the sun found by the gnomon, the sun's parallax must be added, and from the sum must be subtracted the sun's semidiameter, and refraction, which is different at different altitudes; which being done, the correct height of the equator at Rome will be 48° 4′ 12″, the complement of which, or 44° 55′ 46″, is the latitude.

The preceding problem may be resolved more accurately by means of a ray of light let in through a small hole, than by a shadow, thus: make a circular perforation in a brass plate EF (fig. 106.) to transmit enough of the sun's rays to exhibit his image on the floor, or a stage; fix the plate parallel to the horizon in a high place, proper for observation, the height of which above the floor let be accurately measured with a plummet. Let the floor, or stage, be perfectly plane and horizontal, and coloured over with some white substance, to show the sun more distinctly. Upon this horizontal plane draw a meridian line passing through the foot or the centre of the gnomon, AG, *i. e.* the point upon which the plummet falls from the centre of the hole; and upon this line, note the extreme points I and K of the sun's image or diameter, and from each end subtract the image of half the diameter of the aperture, viz. KH and LI; then will HL be the image of the sun's diameter, which, when bisected in B, gives the point on which the rays fall from the centre of the sun.

Now having given the line AB, and the altitude of the gnomon AG, besides the right angle A, the angle B, or the apparent altitude of the sun's centre, is easily found, thus: as AB : AG : : radius: tang. angle B.

GNOSTICS, in church-history, christians so called, it being a name which almost all the ancient heretics affected to take to express that new knowledge and extraordinary light to which they made pretensions: the word gnostic signifying a learned or enlightened person.

GOAT. See CAPRA.

GOAT-SUCKER. See CAPRIMULGUS.

GOBIUS, GOBY, in ichthyology, a genus of fishes

belonging to the order of thoracici. The generic character is, head small; eyes approximated; gill-membrane four rayed; ventral fins united into the form of a funnel. There are eight species, of which the following are the principal.

1. Gobius niger. Common goby. This species grows to the length of six inches; the body is soft, slippery, and of a slender form; the head rather large; the cheeks inflated; the teeth small, and disposed in two rows; from the head to the first dorsal fin is a small furrow; the first dorsal fin consists of six rays, the second, according to Linnæus, of fourteen; the pectoral of sixteen or seventeen, closely set together, and the middlemost the longest; the others on each side gradually shorter; the ventral fins coalesce, and form a sort of funnel, by which these fish are said to affix themselves immoveably to the rocks, for which reason they are called by the name of rock-fish; the tail is rounded at the end; the general colour of the fish is dusky or blackish; but this, on close inspection, is owing to numerous small dusky or blackish specks, accompanied by brown or olive-coloured bars and clouds disposed on a whitish ground; the dorsal and anal fins are of a pale blue; the rays marked with minute black spots. This fish is a native of the Mediterranean and northern seas, and sometimes enters the mouths of the larger rivers, particularly in the beginning of summer, at which season it deposits its spawn on stones near the shores. It is in the number of edible fish, but is in no particular estimation.

2. Gobius lanceolatus. Lance-tailed goby. This species is distinguished by the peculiar form of its tail, which is large in proportion to the animal, and sharp-pointed at the tip; the body is of a lengthened shape, and nearly of an equal diameter throughout; the head is oblong, and truncated in front; the jaws of equal length, and armed with sharp teeth; the gill-covers consist of two small laminæ, and the opening of the gills is large; the vent is situated much nearer the head than the tail; the body is covered with scales, of which those toward the tail are much larger than those on the upper parts. This is a West Indian species: it is found in the rivers of Martinique and some other islands.

3. Gobius cæruleus. Blue goby. Described by Cepede from Commerson. A highly beautiful, though very small, species; colour fine blue, rather paler beneath; tail red, with a black border; length about a decimetre; mouth obtuse; teeth in the lower jaw sharp, and rather longer than those of the upper; eyes rather more distant than in others of the genus; body covered with small rough scales; first dorsal fin triangular, with the rays terminating in lengthened filaments; second dorsal terminated by a ray of twice the length of the rest; vent placed nearly in the middle of the body; tail rounded. Inhabits the seas about the eastern coast of Africa, where it is used by the negroes as a bait for other fish. From the brilliancy of its colours it appears, when swimming in a calm sea, during a bright sunshine, like a small tube of sapphire, tipped with carbuncle.

4. Gobius jozo. Blue-finned goby. This species grows to the length of four or six inches, and is principally distinguished by the blue colour of its fins, and the streaks on the first dorsal fin; the jaws are of equal length, and armed with small sharp teeth; the lateral line runs in a straight direction along the middle of the body. It is a native of the Mediterranean and the Baltic, and commonly frequents the muddy shores, living on sea-insects, &c. It deposits its spawn on the soft mud; and though very prolific, is not observed to be very numerous, owing to the small fry becoming the prey of other fishes; as a food it is held in little or no esteem.

GODFATHERS and Godmothers, persons who at the baptism of infants lay themselves under an indispensable obligation to instruct them, and watch over their conduct. This custom is of great antiquity in the christian church, and was probably instituted to prevent children being brought up in idolatry, in case their parents died before they arrived at years of discretion. The number of godfathers and godmothers is reduced to two in the church of Rome, and three in the church of England; but formerly they had as many as they pleased.

GOLD. See Aurum, and Chemistry.

Gold-wire, a cylindrical ingot of silver, superficially gilt, or covered with gold at the fire, and afterwards drawn successively through a great number of little round holes, of a wire drawing-iron, each less than the other, till it is sometimes no bigger than a hair of the head. See Wiredrawing.

It may be obeved, that before the wire is reduced to this excessive fineness, it is drawn through above 140 different holes, and that each time they draw it, it is rubbed afresh over with new wax, both to facilitate its passage, and to prevent the silver appearing through it.

Gold-wire, *flatted*, is the former wire flatted between two rollers of polished steel, to fit it to be spun on a stick, or to be used flat, as it is without spinning, in certain stuffs, laces, embroideries, &c.

Gold-thread, or *spun-gold*, is a flatted gold, wrapped or laid over a thread of silk, by twisting it with a wheel and iron bobbins.

Manner of forming gold-wire and gold-thread, both round and flat. First, an ingot of silver, of 24 pounds, is forged into a cylinder, of about an inch in diameter; then it is drawn through eight or ten holes, of a large coarse wiredrawing-iron, both to finish the roundness, and to reduce it to about three-fourths of its former diameter. This done, they file it very carefully all over to take off any filth remaining from the forge; they then cut it in the middle: and thus make two equal ingots thereof, each about 26 inches long, which they draw through several new holes, to take off any inequalities the file may have left, and to render it as smooth and equable as possible.

The ingot thus far prepared, they heat it in a charcoal fire; then taking some gold-leaves, each about four inches square, and weighing twelve grains, they join four, eight, twelve, or sixteen of these, as the wire is intended to be more or less gilt; and when they are so joined as only to form a single leaf, they rub the ingots reeking-hot with a burnisher. These leaves being thus prepared, they apply over the whole surface of the ingot, to the number of six, over each other, burnishing or rubbing them well down with the blood-stone, to close and smooth them. When gilt, the ingots are laid anew in a coal fire; and when raised to a certain degree of heat, they go over them a second time with the blood-stone, both to solder the gold more perfectly, and to finish the polishing. The gilding finished, it remains to draw the ingot into wire.

In order to do this, they pass it through 20 holes of a moderate drawing-iron, by which it is brought to the thickness of the tag of a lace: from this time the ingot loses its name, and commences gold-wire. Twenty holes more of a lesser iron leave it small enough for the least iron, the finest holes of which last, scarcely exceeding the hair of the head, finish the work.

To dispose the wire to be spun on silk, they pass it between two rollers of a little mill; these rollers are of nicely polished steel, and about three inches in diameter. They are set very close to each other, and turned by means of a handle fastened to one of them, which gives motion to the other. The gold-wire in passing between the two is rendered quite flat, but without losing any thing of its gilding, and is rendered so exceedingly thin and flexible, that it is easily spun on silk thread, by means of a hand-wheel, and so wound on a spool or bobbin.

Gold-*beating*. They first melt a quantity of pure gold, and form it into an ingot: this they reduce, by forging, into a plate of about the thickness of a sheet of paper; which done, they cut the plate into little pieces about an inch square, and lay them in the first or smallest mould to begin to stretch them; after they have been hammered here awhile with the smallest hammer, they cut each of them into four, and put them into the second mould, to be extended further.

Upon taking them hence, they cut them again into four, and put them into the third mould, out of which they are taken, divided into four as before, and laid in the last or finishing mould, where they are beaten to the degree of thinness required.

The leaves thus finished, they take them out of the mould, and dispose them into little paper books, prepared with a little red bole, for the gold to stick to: each book ordinarily contains 25 gold leaves. There are two sizes of these books: 25 leaves of the smallest only weigh five or six grains, and the same number of the largest nine or ten grains.

It must be observed, that gold is beaten more or less, according to the kind or quality of the work it is intended for; that for the gold wire-drawers to gild their ingots with is left much thicker than that for gilding the frames of pictures, &c. See Gilding.

Gold, *burnished*, that smoothed or polished with a burnisher.

Gold, *mosaic*, that applied in pannels, on proper ground, distributed into squares, lozenges, and other compartments, parts whereof is shadowed to heighten or raise the rest. See Mosaic.

Gold, *shell*, that used by the illuminers, and with which we write gold letters. It is made of the parings of leaf-gold, and even of the leaves themselves, reduced into an impalpable powder, by grinding on a marble with honey. After leaving it to infuse some time in aquafortis, they put it in shells, where it sticks. To use it, they dilute it with gum-water, or soap-water.

Gold, *pure*, that purged by fire of all its impurities, and all alloy. The moderns frequently call it gold of 24 caracts, but in reality there is no such thing as gold so very pure, and there is always wanting at least a quarter of a caract. Gold of 22 caracts has one part of silver, and another of copper; that of 23 caracts has half a part (that is, half a twenty-fourth) of each. See Caract.

Gold, in heraldry, is one of the metals, more usually called by the French name *or*.

GOLDEN number, in chronology, a number showing what year of the moon's cycle any given year is. See Cycle.

From what has been said under Cycle of the moon, it appears that the golden number will not show the true change of the moon for more than 312 years, without being varied. It is to be observed, that the golden number is not so well adapted to the Gregorian as to the Julian calendar; the epact being more certain in the new style, to find which the golden number is of use. See Epact, and Cycle.

Golden rule, in arithmetic, is also called the rule of three, and the rule of proportion. See Arithmetic.

GOLDFINCH. See Fringilla.

GOLDSMITH, or, as some choose to express it, silversmith, an artist who makes vessels, utensils, and ornaments, in gold and silver.

The goldsmith's work is either performed in the mould, or beaten out with the hammer, or other engine. All works that have raised figures are cast in a mould, and afterwards polished and finished: plates or dishes of silver or gold are beaten out from thin flat plates; and tankards, and other vessels of that kind, are formed of plates soldered together, and their mouldings are beaten, not cast. The business of the goldsmith formerly required much more labour than it does at present; for they were obliged to hammer the metal from the ingot to the thinness they wanted: but the flatting-mills now in use reduce metals to the thinness that is required, at a very small expense. The goldsmith is to make his own moulds, and for that reason ought to be a good designer, and have a taste in sculpture; he also ought to know enough of metallurgy to be able to assay mixed metals, and to mix the alloy. See Assaying.

The goldsmiths in London employ several hands under them for the various articles of their trade; such are the jeweller, the snuff-box and toy-maker, the silver turner, the gilder, the burnisher, the chaser, the refiner, and the gold-beater. See Jeweller, &c.

Goldsmiths are superior tradesmen; their wares must be assayed by the wardens of the company of this name in London, and marked: and gold is to be of a certain touch. No goldsmith may take above one shilling the ounce of gold, besides what he has for the fashioning, more than the buyer may be allowed for it at the king's exchange; and here any false metal shall be seized and forfeited to the king. The cities of York, Exeter, Bristol, &c. are places appointed for the assaying wrought plate of goldsmiths; also a duty is granted on silver plate of sixpence an ounce, &c. Plate made by goldsmiths shall be of a particular fineness, on pain of forfeiting 10*l.* and if any parcel of plate sent to the assayers is discovered to be of a coarser alloy than the respective standards, it may be broken, and defaced; and the fees for assaying are particularly limited.

GOMPHIA, a genus of the decandria monogynia class and order. The calyx is five leaved; the corolla five-petalled; berries two; (1 to 5) in a large receptacle. Seed solitary. There are three species, trees of the East and West Indies.

GOMPHRÆNA, *globe amaranth*, a genus of the di-

gynia order, in the pentandria class of plants, and in the natural method ranking under the 54th order, miscellaneæ. The calyx is coloured; the exterior one triphyllous, or diphyllous, with two carinated convenient leaflets; the nectarium cylindrical, with ten teeth; the capsule monospermous. There are nine species, but only one of them is commonly cultivated in our gardens, viz. the globosa, or globe amaranth. It has an upright stalk branching all round, two or three feet high, with oval, lanceolate, and opposite leaves; and every branch and side-shoot terminated by a close globular head of flowers, composed of numerous very small starry florets, closely covered with dry scaly calices placed imbricatim, persistent, and beautifully coloured purple, white, red, or striped and variegated. The florets themselves are so small, and closely covered with the scaly calices, that they scarcely appear. The numerous closely placed scaly coverings being of a dry firm consistence, coloured and glittering, collected into a compact round head, about the size of an ordinary cherry, make a fine appearance. They are annual plants, natives of India, and require artificial heat to raise and forward them to a proper growth, so that they may flower in perfection, and produce ripe seed. They flower from June to November; and if the flowers are gathered when at full growth, and placed out of the sun, they will retain their beauty several months.

GONARCHA, in antiquity, a dial delineated on several surfaces, or planes, some horizontal, others erect, oblique, &c.

GONATOCARPUS, a genus of the tetrandria monogynia class and order. The corolla is four cleft, drupe eight-cornered, one-seeded. There is one species, an annual of Nogasaki.

GONDOLA, a flat boat, very long and narrow, chiefly used at Venice to row on the canals. The word is Italian, gondola. Du Cange derives it from the vulgar Greek κουντιλας, "a bark," or "little ship;" Lancelot deduces it from γονδυ, a term in Athenæus for a sort of vase. The middle-sized gondolas are upwards of thirty feet long and four broad; they always terminate at each end in a very sharp point, which is raised perpendicularly to the full height of a man. The address of the Venetian gondoleers, in passing along their narrow canals, is very remarkable: there are usually two to each gondola, and they row by pushing before them. The fore man rests his oar on the left side of the gondola: the hind man is placed on the stern, that he may see the head over the tilt or covering of the gondola, and rest his oar, which is very long, on the right side of the gondola. Gondola is also the name of a passage-boat of six or eight oars, used in other parts of the coast of Italy.

GONDOLA-SHELL, in natural history. See DOLIUM.

GONHORRHŒA. See SURGERY.

GONIOMETRY, a method of measuring angles, so called by M. de Lagny, who gave several papers, on this method, in the memoirs of the Royal Academy. M. de Lagny's method of goniometry consists in measuring the angle with a pair of compasses, and that without any scale whatever, except an undivided semicircle. Thus, having any angle drawn upon paper, to be measured, produce one of the sides of the angle backwards behind the angular point; then with a pair of fine compasses describe a pretty large semicircle from the angular point as a centre, cutting the sides of the proposed angle, which will intercept a part of the semicircle. Take then this intercepted part very exactly between the points of the compasses, and turn them successively over upon the arc of the semicircle, to find how often it is contained in it, after which there is commonly some remainder: then take this remainder in the compasses, and in like manner find how often it is contained in the last of the integral parts of the first arc, with again some remainder: find in like manner how often this last remainder is contained in the former; and so on continually, till the remainder become too small to be taken and applied as a measure. By this means he abtains a series of quotients, or fractional parts, one of another, which being properly reduced into one fraction, give the ratio of the first arc to the semicircle, or of the proposed angle to two right angles, or 180 degrees, and consequently that angle itself in degrees and minutes.

Thus suppose the angle BAC (Pl. LXIV. Mis. fig. 107.) be proposed to be measured. Produce BA towards *f*; and from the centre A describe the semicircle *a b c f*, in which *a b* is the measure of the proposed angle. Take *ab* in the compasses, and apply it four times on the semicircle, as at *b*, *c*, *d*, and *e*; then take the remainder *fe*, and apply it back upon *ed*, which is but once, viz. at *g*; again take the remainder *gd*, and apply it five times on *ge*, as at *h*, *i*, *k*, *l*, and *m*; lastly, take the remainder *m e*, and it is contained just two times in *m l*. Hence the series of quotients is 4, 1, 5, 2; consequently the fourth or last arc *em* is $\frac{1}{2}$ the third *ml* or *gd*, and therefore the 3d arc *gd* is $\frac{1}{5\frac{1}{2}}$, or $\frac{2}{11}$ of the 2d arc *ef*; and therefore, again this 2d arc *ef* is $\frac{1}{1\frac{2}{11}}$, or $\frac{11}{13}$ of the 1st arc *ab*; and consequently this 1st arc *ab* is $\frac{1}{4\frac{11}{13}}$, or $\frac{13}{63}$ of the whole semicircle *af*. But $\frac{13}{63}$ of 180° are $37\frac{1}{7}$ degrees, or $37°\ 8'\ 34''\frac{2}{7}$, which therefore is the measure of the angle sought. When the operation is nicely performed, this angle may be within two or three minutes of the truth; though M. de Lagny pretends to measure much nearer than that.

GONIUM, a genus of Vermes, of the order infusoria. Worm very simple, flat, angular, invisible to the naked eye. There are five species. The pectoral, quadrangular, pellucid, with 16 spherical molucles, found in pure water; molecules oval, nearly equal in size, set in a quadrangular membrane, like diamonds in a ring, the lower ones a little larger than the rest. See Adams on the Microscope.

GOOD BEHAVIOUR: surety for the good behaviour is the bail or pledge for any person that he shall do or perform such a thing, as surety for the peace is the acknowledging a recognizance or bond to the king, taken by a competent judge of record, for keeping the king's peace. Dalt. c. 116.

A binding to the good behaviour is not by way of punishment; but it is to show, that when a man has broken the good behaviour, he is not to be trusted. 12 Mod. 566.

Justices of peace may chastise rioters, barrators, and other offenders, and also imprison and punish them ac-

cording to law, and by discretion and good advisement; and also bind persons of evil fame to the good behaviour, &c. 34 Ed. III. c. 1.

This statute being penned in such general words, seems in a great measure to have left it to the discretion of justices of the peace, to determine what persons should be bound to their good behaviour; and consequently seems to empower them, not only to bind over those who seem to be notoriously troublesome, and likely to break the peace, as eves-droppers, &c. but also those who are publicly scandalous, or contemners of justice, &c. as haunters of bawdy-houses, or keepers of lewd women in their own houses; common drunkards, or those who sleep in the day and go abroad in the night, or such as keep suspicious company, or such as are generally suspected as robbers; or such as speak contemptuous words of superior magistrates, as justices of peace, mayors, &c. being in the actual execution of their office, or of inferior officers of justice, as constables, &c. being in the actual execution of their office; but it seems that rash, quarrelsome, or unmannerly words, spoken by one private person to another, unless they directly tend to a breach of the peace, are not sufficient cause to bind a man to his good behaviour. 1 Haw. 133.

GOODENIA, a genus of the pentandria monogynia class and order. The corolla is five-cleft; anthers linear; stigma cup-shaped, ciliated; caps. two-celled, two valved. Seeds many, imbricated. There are nine species, shrubs of South Wales.

GOOSE. See ANAS.

GOOSEBERRY, grossularia. See RIBES.

GOOSE-EMBER. See MARGUS.

GOOSE-NECK, in a ship, a piece of iron fixed on the end of the tiller; to which the laniard of the whip-staff, or the wheel-rope comes, for steering the ship.

GOOSE-WING, in the sea-language. When a ship sails before, or with, a quarter-wind on a fresh gale, to make the more haste, they launch out a boom, and sail on the lee-side; and a sail so fitted, is called a goose-wing.

GORDIUS, the *hair-worm*, a genus of insects belonging to the class of vermes intestina. There are several species: 1. The aquaticus, or water hair-worm, is 10 or 12 inches in length, and of about the thickness of a horse-hair; its skin is smooth, and somewhat glossy, without furrows; its colour pale-yellowish white all over, except the head and tail, which are black and glossy. The body is rounded, and very slender in proportion to its length; the mouth is small, and placed horizontally; the jaws are both of the same length, and obtuse at their extremities. This species is common in our fresh waters, more especially in clay, through which it passes as a fish does through the water, and is the author of many springs. It is a variety of this worm that in Guinea, and in some other of the hot countries, gets into the flesh of the natives, and occasions great mischief; with us, though frequent enough in water where people bathe, it never attempts this. 2. The argillaceous, or clay hair-worm, is only a variation of the preceding one in colour, being yellowish at the extremities. It chiefly inhabits the clay; Linnæus calls that its proper element, from its being generally dug out of it. 3. The medinensis, or muscular hair-worm, is all over of a pale yellowish colour. It is a native of both Indies; frequent in the morning dew, whence it enters the naked feet of the slaves, and occasions a disease much known in those countries, and to which children are very liable; it creates the most troublesome itchings, and too often excites a fever and inflammation. It particularly attacks the muscles of the arms and legs, whence it may be drawn out by means of a piece of silk or thread tied round the head; but the greatest caution is necessary in this simple operation, lest the animal, by being strained too much, should break; for if any part remains under the skin, it quickly grows with redoubled vigour, and becomes a cruel, and sometimes fatal enemy to the poor slaves in particular. Baths with infusions of bitter plants, and all vermifuges, destroy it. 4. The marinus, or sea hair-worm, is filiform, twisted spirally and lying flat, about half an inch in length; of a whitish colour, smooth, and scarcely diminishing at the head. It is as great a tormentor of herrings, bleaks, and various other fish, as the gordius medinensis is of man. The fish, when infested with these animals, rise to the surface, and tumble about as if in great agony.

GORDONIA, a genus of the polyandria order, in the monadelphia class of plants. The calyx is simple; the style five-cornered, with the stigma quinquefid; the capsule quinquelocular; the seeds two-fold, with a leafy wing. There are three species. The lasianthus is a tall and very straight tree, with a regular pyramidal head. Its leaves are shaped like those of the common bay, but serrated. It begins to blossom in May, and continues bringing forth its flowers the greatest part of the summer. The flowers are fixed to footstalks, four or five inches long; are monopetalous, divided into five segments, encompassing a tuft of stamina headed with yellow apices; these flowers, in November, are succeeded by a conic capsula, having a divided calyx. The capsula, when ripe, opens and divides into five sections, disclosing many small half-winged seeds. This tree retains its leaves all the year, and grows only in wet places, and usually in water. The wood is somewhat soft; yet Mr. Catesby mentions his having seen some beautiful tables made of it. It grows in Carolina, but not in any of the more northern colonies.

GORGONIA, in natural history, a genus of zoophytes, which formerly were called ceratophytons, and are known in English by the names of sea-fans, sea-feathers, and sea-whips. Linnæus and Dr. Pallas consider them as of a mixed nature in their growth, between animals and vegetables: but Mr. Ellis shows them to be true animals of the polype kind, growing up in a branched form resembling a shrub, and in no part vegetable. They differ from the fresh-water polype in many of the qualities, and particularly in producing from their own substance a hard and solid support, serving many of the purposes of the bone in other animals. This is formed by a concreting juice, thrown out from a peculiar set of longitudinal parallel tubes, running along the internal surface of the fleshy part: in the coats of these tubes are a number of small orifices, through which the osseous liquor exudes, and concreting, forms the layers of that hard part of the annular circles, which some, judging from the consistence rather than the texture, have erroneously denominated wood. The surface of the gorgonia is composed of a kind of scales, so well adapted to each other, as to serve for defence rom external injuries; and the

flesh, or, as some have called it, the bark or cortex, consists of proper muscles and tendons for extending the opening of their cells; for sending forth from thence their polype suckers in search of food, and for drawing them in suddenly, and contracting the sphincter muscles of these starry cells, in order to secure these tender parts from danger; and also of proper secretory ducts, to furnish and deposit the osseous matter that forms the stem and branches as well as the base of the bone. Mr. Ellis affirms, that there are ovaries in these animals, and thinks it very probable that many of them are viviparous. See CORALLINES, and ZOOPHYTES.

GORE, in heraldry, one of the abatements, which, according to Guillim, denotes a coward. It is a figure consisting of two arch lines drawn one from the sinister chief, and the other from the sinister base, both meeting in an acute angle in the middle of the fess point.

GORE, in law, signifies a narrow slip of ground.

GOREING, in the sea-language, sloping. A sail is cut goreing, when it is cut sloping by degrees, and is broader at the clew than at the earing, as all topsails and top-gallant sails are.

GORGE, in fortification, the entrance of the platform of any work. See FORTIFICATION.

In all the outworks, the gorge is the interval betwixt the wings on the side of the great ditch, as the gorge of a ravelin, half-moon, &c. These, it is to be observed, are all destitute of parapets; because if there were any, the besiegers, having taken possession of the work, might use it to defend themselves from the shot of the place; which is the reason that they are only fortified with palisadoes, to prevent a surprise.

The gorge of a bastion is nothing but the prolongation of the curtins from their angle with the flanks, to the centre of the bastion where they meet. When the bastion is flat, the gorge is a right line, which terminates the distance between the two ranks.

GORGED, in heraldry, the bearing of a crown, coronet, or the like, about the neck of a lion, a swan, &c. and in that case it is said, the lion or cygnet is gorged with a ducal coronet, &c.

GORTERIA, a genus of the class and order syngenesia polygamia frustranea class and order. The calyx is intricate; corolla of the ray ligulate; down, woolly; receptacle, naked. There are 13 species, mostly shrubby plants of the Cape.

GOSHAWK. See FALCO.

GOSSAMER, is the name of a fine filmy substance, like cobweb, which is seen to float in the air in clear days in autumn, and is more observable in the stubble-fields, and upon furze and other low bushes. This is probably formed by the flying-spider, which, in traversing the air for food, shoots out these threads from its anus, which are borne down by the dew, &c.

GOSSYPIUM, or cotton; a genus of the polyandria order, in the monadelphia class of plants, and in the natural method ranking under the 37th order, columniferæ. The calyx is double, the exterior one trifid; the capsule quadrilocular; the seeds wrapt in cotton-wool. There are six species, all of them natives of warm climates. 1. The herbaceum, or common herbaceous cotton, has an herbaceous smooth stalk two feet high, branching upwards; five-lobed smooth leaves; and yellow flowers from the ends of the branches, succeeded by roundish capsules full of seed and cotton. 2. The hirsutum, or hairy American cotton, has hairy stalks branching laterally two or three feet high; palmated, three and five-lobed hairy leaves; and yellow flowers, succeeded by large oval pods furnished with seeds and cotton. 3. The barbadense, or Barbadoes shrubby cotton, has a shrubby stalk branching four or five feet high, three-lobed smooth leaves; glandulous underneath; and yellow flowers succeeded by oval pods; containing seeds and cotton. 4. The arboreum, or tree cotton, has an upright woody perennial stalk, branching six or eight feet high; palmated, four or five-lobed smooth leaves, and yellow flowers, succeeded by large pods filled with seeds and cotton. The first three species are annual, but the fourth is perennial both in root and stalk. In warm countries these plants are cultivated in great quantities in the fields for the sake of the cotton they produce; but the first species is most generally cultivated. The pods are sometimes as large as middling-sized apples, closely filled with the cotton surrounding the seed. They are propagated by seeds.

The American islands produce cotton shrubs of various sizes, which rise and grow up without any culture, especially in low and marshy grounds. Their produce is of a pale red, some paler than others, but so short that it cannot be spun. None of this is taken to Europe, though it might be usefully employed in making hats. The little that is picked up serves to make mattrasses and pillows.

The cotton shrub that supplies our manufactures requires a dry and stony soil, and thrives best in grounds that have already been tilled. Not but the plant appears more flourishing in fresh lands than in those which are exhausted; but while it produces more wood, it bears less fruit. A western exposure is fittest for it. The culture of it begins in March and April, and continues during the first spring-rains. Holes are made at seven or eight feet distance from each other, and a few seeds thrown in. When they are grown to the height of five or six inches, all the stems are pulled up, except two or three of the strongest. These are cropped twice before the end of August. This precaution is the more necessary, as the wood bears no fruit till after the second pruning; and if the shrub was suffered to grow more than four feet high, the crop would not be the greater, nor the fruit so easily gathered. The same method is pursued for three years; for so long the shrub may continue, if it cannot conveniently be renewed oftener with the prospect of an advantage that will compensate the trouble. This useful plant will not thrive if great attention is not paid to pluck up the weeds that grow about it. Frequent rains will promote its growth, but they must not be incessant. Dry weather is particularly necessary in the months of March and April, which is the time of gathering the cotton, to prevent it from being discoloured and spotted. When it is all gathered in, the seeds must be picked out from the wool with which they are naturally mixed. This is done by means of a cotton-mill, which is an engine composed of two rods of hard wood, about 18 feet long, 18 lines in

circumference and fluted two lines deep. They are confined at both ends, so as to leave no more distance between them than is necessary for the seed to slip through. At one end is a kind of little millstone, which, being put in motion with the foot, turns the rods in contrary directions. They separate the cotton, and throw out the seed contained in it.

GOUANIA, a genus of the monoecia order, in the polygamia class of plants. The calyx of the hermaphrodite is quinquefid; there is no corolla; there are five antheræ covered with an elastic calyptra or hood; the style trifid; the fruit, inferior to the receptacle of the flower, divisible into three seeds. The male is like the hermaphrodite, but wanting stigma and germen. There is one species, a shrubby plant of St. Domingo.

GOUGE, an instrument or tool used by divers artificers; being a sort of round hollow chisel, for cutting holes, channels, grooves, &c. either in wood or stone.

GOURD. See Cucurbita.

GOUT. See Medicine.

GRACE, *act of*, an act of parliament for a general and free pardon, and for setting at liberty insolvent debtors.

Grace, *days of*, in commerce. See Bills of Exchange.

GRACULA, the grakle, in ornithology, a genus belonging to the order of picæ. The bill is convex, cultrated, and bare at the point; the tongue is not cloven, but is fleshy and sharp; it has three toes before and one behind. 1. The religiosa, lesser grakle, or Indian stare, is about the size of a blackbird; the bill an inch and a half long, and of an orange colour. The general colour of the plumage is black, glossed with violet, purple, and green, in different reflections of light; on the quills is a bar of white; the feathers and legs are an orange-yellow, and the claws of a pale brown. This species, which is found in several parts of the East Indies, in the Isle of Hainan, and almost every isle beyond the Ganges, is remarkable for whistling, singing, and talking well, much better than any of the parrot genus, and in particular very distinct. Its food is of the vegetable kind. Those kept in this climate are observed to be very fond of cherries and grapes; if cherries are offered to one, and it does not immediately get them, it cries and whines like a young child, till it has obtained its desire. It is a very tame and familiar bird. 2. The barita, or boat-tailed grakle, is about the size of a cuckow. The bill is sharp, black, and an inch and a half in length; the general colour of the plumage is black, with a gloss of purple, especially on the upper parts; the legs and claws are black, the latter hooked. There is a singularity in the folding up of the tail feathers, which, instead of forming a plain surface at top, sink into a hollow like a deep gutter. It always carries its tail expanded when on the ground, folding it up in the above singular manner only when perched or flying. It inhabits Jamaica; and it feeds on maize, on beetles and other insects, as well as on the fruit of the banana. It is likewise common in North America, keeping company with the flocks of the maize-thieves, and red-winged oriole. These breed in the swamps, and migrate in September, after which none are seen. 3. The quiscula, purple jackdaw, or Barbadoes blackbird, is about the size of a blackbird: the male bird is black, but most beautifully and richly glossed with purple; especially on the head and neck. The female is wholly of a brown colour, deepest on the wings and tail. This species inhabits Carolina, Mexico, and other parts of North America, also Jamaica. These birds for the most part feed on maize, whence the name of maize-thieves has been given them; but this is not their only food, for they are known also to feed on many other things. In spring, soon after the maize-seed is put into the ground, they scratch it up again; and as soon as the leaf comes out, they take it up with their bills, root and all; but when it is ripe they do still more damage, for at that time they come in troops of thousands, and are so bold, that if disturbed in one part of the field they only go to another. In New Jersey and Pennsylvania three pence per dozen was once given for the dead bodies, and by means of the premium they were nearly extirpated in 1750; when the persecution of them was abated on account of the increase of worms which had taken place in the meadows, and which in the preceding year had left so little hay in New England as to occasion an importation from other parts. The grakles were therefore again tolerated, as it was observed that they fed on these worms till the maize was ripe. These birds build in trees. They are said to pass the winter in swamps which are quite overgrown with wood, thence only appearing in mild weather; and after the maize is got in, are content to feed on other things, as the aquatic tare-grass, and if pressed by hunger, buck-wheat and oats, &c.: they are said also to destroy that pernicious insect the bruchus pisi. Their note is pretty and agreeable, but their flesh is not good to eat. 4. The cristatella, or Chinese starling, is a little bigger than a blackbird. The bill is yellow or orange, and the general colour of the plumage blackish with a tinge of blue; the legs are of a dull yellow. These birds, which are said to talk and whistle very well, are common in China, where they are very much esteemed, and the figures of them are seen frequently in Chinese paintings. Their food is rice, insects, worms, and such-like. They are seldom taken to England alive, requiring the greatest care in the passage. There are eight other species of gracula.

GRADUATION, in mathematics, the act of dividing any thing into degrees, or equal parts.

GRAFTING, or *graffing*, in gardening, is the insertion of a scion into a stock or stem raised for the purpose, and is necessary to the ensuring of good fruit; *i. e.* to have the same (or at least with little difference) produced on the new tree, as that of the old one whence the graft was taken: it is sometimes performed on the branches of trees, and may be on the roots, a piece being raised out of the ground for the purpose.

If the seeds of fruit were left to grow up to trees without grafting, they would produce a different kind from that they came from; by chance a better, but most commonly a worse. The varieties of fruit we have, were obviously obtained from seedling stocks, without grafting.

Grafting is like planting upon a plant, for though there is a union of the parts, there is in fact little other communication than a root has with the ground. The scion, or bud, draws nourishment from the stock, but no other than is properly adapted to its own peculiar vessels, and which it alters so as to become exclusively its own.

The art of grafting is a very curious discovery, and though it requires some ingenuity to perform it, a few trials may make it familiar, and it will prove an agreeable source of amusement and satisfaction. By being able to graft, young trees may be always at hand for replacing old, or unsuccessful ones; and the pleasure of obliging a friend from our stock in this way, is peculiarly gratifying.

Skill in this ingenious art is clearly best obtained by seeing the work performed; and at first trial, to have an adept at the elbow, would be a great advantage. There are few gardeners (even by profession), however, that practise this work, owing to the great number of nurserymen ready to supply trees. But though they raise fine trees, much disappointment has often happened in dealing with them (particularly in the sort); which might be avoided, by a man's being able to raise good trees for himself. Directions precisely descriptive of the business of grafting, are therefore here attempted, and if once understood, trials should be made without minding the discouragement of a few failures; for practice will make perfect.

Proper stocks being ready, and scions or buds procured, there will be wanting a good sharp narrow-bladed penknife, and a sharp smooth-edged pruning-knife, with some well-wrought loam or clay, and some good new bass, or strong yarn. The clay should be made up as mortar, mixed with short hair, or fine chopt hay, with a little cow-dung, and prepared a day or two beforehand; or if longer the better, being beaten up afresh with a little water every day.

The first thing to be done is, to cut off the head of the stock at the proper height, and in a fair part of the bark, making a smooth flat top; if the stock is too strong for the knife, and a saw is used, it must be smoothed with the knife after. The most proper size for stocks, is from half an inch to an inch diameter: a little more or less, however, may do. When a stock is too little, the scion is apt to overgrow it, and when too big, the scion does not so well, or so soon, cover the stock, as might be wished; yet stocks of any size can be used by one mode of grafting or other.

Dwarf trees are to be grafted within six inches of the ground, and standards as high as the stock will well bear, considering whether they are to be half or full standards; the former at about three or four feet, the latter at five or six. But trees designed for standards, may be grafted or inoculated at a lower height, the graft being trained to the desired length, by keeping it to a single stem.

The scions should be healthy and strong (not however of a soft, sappy, luxuriant growth), and taken from the outsides of fruitful trees, where the juices of the wood have been properly digested by sun and air; they should be taken (if it may be) from trees just in their prime, or at full bearing, and not before. Let them be cut two or three weeks sooner than wanted, and if kept longer they may not hurt, for they had better be cut a little too soon than too late, at full length, without any side shoots.

Let the scions of pears, plums, and cherries, be cut from the middle to the end of January, and at farthest not beyond the middle of February; the season must, however, somewhat govern. Keep them all over in dry mould, close under a south wall, or some shelter, covering them with straw in wet or severe weather. Some preserve them in a cool room, where they will do without mould, but it would be better to set them upon end in a garden-pot, half their length with mould or sand, nearly dry.

Scions cut early are prevented from getting too forward in bud: for if the buds begin to start, and look white, they seldom take. By having them as long as they may be kept before used, the sap of the stock gets in forwardness; for it must first begin to stir, and so be ready to push itself quickly into the scion (now somewhat exhausted), to form an union with it.

The middle of scions is fittest for the purpose; but do not cut off the tops till they are brought out to graft, for they keep best in length. If scions are to be transported to any distance, let their ends be stuck two or three inches in clay, and so matted round in a bundle; or, if wrapped round with a fine hay-rope, and smeared over with cow-dung, clay, or a strong earth, they will not soon wither.

Some gardeners say, scions should be only of the last year's growth, and others, that the wood of the year before is best; but it is so far a matter of indifference that they will take much older, though perhaps, not so certainly. As a medium, if a little of the former year's wood is cut with a scion of the last, and this older wood used for the part grafted, it will be found to answer, in covering the stock sooner; though it must be acknowledged, that all new wood is the common practice of those who raise trees for sale; which circumstance is ordinarily, a presumptive proof of right. If wood, however, of a year's growth is not strong enough, then, at least, some of the old wood ought to be cut with it; and the bigger the stock is, the more this practice commends itself, as the barks will be somewhat more equal in thickness.

Proceeding to graft, take off a little of the lower end of the scion first, and then cut it in length, so as to have three or four eyes to appear above the claying; two eyes will be sufficient for a standard, but four are better for a dwarf that is to be trained. In cutting scions into lengths, let the top eye be just in front or just behind, but rather the former. Use not (except upon necessity) the upper part of a scion, as the wood is too raw for the purpose, and will be shrivelled; yet strong scions (properly inserted) seldom miss through drought; indeed they will take sooner than if quite fresh cut and full of sap.

The time for grafting is usually from mid-February to mid-March; but in a forward season sooner, and in a backward one sometimes later.

Cleft-grafting has been the most common method of progation, and though it is not the neatest, yet it is a certain and easy way to young practitioners. The stocks for this mode of grafting should be strong, about three quarters of an inch diameter, or more; but it may be used with very young stocks, having scions of like thickness.

Cut off the head as before directed, so as to have (on the sunny side) a smooth part in the stock, where the scion is to be placed, and cutting a part of the stock off slopewise, opposite to this place, leave the top or the crown of the stock, about half an inch wide.

Then cleave the stock with a strong knife, or thin sharp chisel, about two inches deep, as near the middle as possible, so as not to divide the pith, and if any roughness appears in the slit, smooth it off with a penknife;

but something of the wedge kind must be put into the slit to keep it open to receive the scion, leaving proper room to put it in. Cut the scion on each side to the form of a wedge at bottom, an inch or more long, making that side which is to be placed inwards in the stock, thinner by about one-third. Put the scion in, so that its bark and that of the stock may be level; and consequently that the two barks may unite and run into each other; for on this one principle depends the whole art of grafting. If the bark of the stock is thick, let the bark of the scion sink in a trifle, as the current of sap that unites them, runs betwixt the bark and wood. The scion being placed, take the wedge out that kept the stock open; yet if the stock is so strong as to pinch the scion too hard, ease it by a little bit of dry wood to be left in the cleft; so, however, as not to loosen the graft, which must be held firmly: or if the stock is very strong, the wedge of the scion may be nearly of equal thickness, inside and out, which cases the barked part.

The graft must be nicely whipped round with wet bass pulled tight, and the whole clayed over to an inch above and half an inch below, smoothing it off taper, with a trowel or knife dipped in water. And as this is done with a view to keep out wet, sun, and air, if the clay falls off or cracks, it must be immediately repaired, till the season comes to take off the bandage, which is about Midsummer, or rather sooner; yet at this time some clay should be still kept on the top, to secure the cleft from wet, and so continued till the cleft is grown up.

If it is desired to put in two scions, to form a tree for the wall, or espallier, there should be two clefts parallel to one another, one on each side the pith. Some put in two scions, merely in case one should miss; but it is not advisable. It need hardly be observed, that in this case the crown must be left whole.

Whip-grafting has the advantage of cleft-grafting in neatness, and not requiring the stocks to be so old by a year or two, as very small ones will do in this way; for the stock is directly covered by the scion, and it takes with certainty if properly performed. Scions suitable to proper stocks cannot however always be had. Stock and scion are to be both of a size; or nearly so is better, the stock having the advantage in bigness; for thus it is not so likely to be overgrown, as it happens when the scion is of a more free nature. When the stock is overgrown by the scion, it will give it some opportunity to thicken, by slitting the bark through downwards, in two or three places. This circumstance is not, however, material in dwarf trees.

Having cut the head of the stock off, and the scion to its proper length, slope the lower end of the scion about an inch and a half, and to a point; then cut the stock to answer it (the cut of the stock, however, may be a trifle wider and longer) bark against bark, and tie them together exactly to their place, and clay it. But for the greater certainty of keeping a scion to the part, cut it so as to leave a small shoulder at the top of the slope, and the stock so as to leave a narrow bit of its crown to answer it, and to hold it.

There is a sort of whip-grafting that has been denominated slicing, or packing, which differs only from that just described, in this: that the stock is of any size; and this is performed by cutting the scion to a face, as before, and then taking off a slice from the (beheaded) stock, choosing a gibbous part of it so as exactly to correspond with the cut surface of the scion, taking care to fit them so that the scion may stand erect (or nearly) when clapped to. Shouldering is commonly practised also in this way.

Grafting in the bark, or *crown-grafting*, is perhaps as good a way as any, both for ease of operation and certainty of success; but it will hardly suit any other fruit than apples or pears, as other scions will be past use (most likely) before the bark of the stocks will peel, as the time for this business is towards the end of March, or beginning of April.

The head being cut off, make a straight slit down and through the bark from the top, at the place destined for the graft, which should be rather southerly or westerly. This score down the bark should be nearly as long as the slope cut of the scion, which may be one and a half or two inches. Loosen the bark a little at the top of the score, and then with some smooth instrument of dry hard wood, ivory, bone, or silver, rather than iron or steel, open the bark sufficiently to receive the scion, by pushing the instrument down a trifle below the bottom of the slit. This instrument should be thin, tapered and rounded towards the point, to suit the shape of the scion's face; one side of it flat, and the other a little convex, the flat side being applied to the wood of the stock; let it be rather narrower than the scion, that it may not loosen the bark too wide.

Cut a bit of the bark of the scion smooth off at the bottom that it may not turn up in pushing down. It will be proper to cut the scion with a small shoulder, to rest upon the stock. And because when the scion is in, it will bear the bark up hollow from the stock, score the bark on each side the scion, so that it may fall close to the stock, and to the edges of the scion. Bind and clay neatly. In this way of grafting there is a sort of agreement between the scion and stock necessary; the scion not being too big, or the stock too small, to prevent a proper bedding. If more than one scion is not put in, the stock on the opposite side to the scion should be sloped up about two inches in length, to half its thickness.

This way of grafting is used most properly with strong stocks; and sometimes is applied to large branches, and even trunks of old trees, to change the sorts or renew the wood. In proportion to the largeness of which, from two to five or six scions are put in, and sometimes of different sorts; and if the stock is large, the more the better, as it heals over the sooner, and as they insure the life of the stock, by receiving and carrying off the sap; in which respect a single branch of the head of an old stock may be left on, for the sap to pass off by when it begins to stir.

Side-grafting is done in the bark, much like inoculation, a scion being inserted instead of a bud; but remember, there must be a fluent sap first, *i. e.* the bark must part readily from the wood, before this mode of grafting is attempted. The head of the stock is not to be cut off, only thinned a little if it is large, and the side shoots taken away. The bark of the stock, where the insertion of the scion is to be, must be cut through in the form of the letter T, as wide and as long as is sufficient to receive the scion, cut as before, with a slope face of at least an inch long, taking advantage, (if it may be) of a part

of the stock that is a little gibbous. Let the bark of the stock be neatly raised to receive it, but yet no more than necessary; a little bit of the bark may be sliced off the part that is over the cross cut, to receive the scion the better.

Approach-grafting, or *inarching*, is performed in April or May, when the stock we would graft, and the tree we would propagate, grow so near together, as to be conveniently in contact, and the nearer the graft and the stock are of a size the better. This mode of propagation is esteemed the surest of all; and in truth, some things cannot be so well propagated any other way. It is a method that is, or can be, seldom used for common fruit-trees: but if any one wishes to try the experiment, the stock or stocks must be planted at least a year before, first making the soil good, as it may need it, being so near another tree, for it of course must be close.

Plants in pots or tubs being easily brought together, are frequently propagated this way; so that inarching is used much in green-houses and hot-houses for various things, as oranges, lemons, pomegranates, jasmines, and vines sometimes; oranges and lemons thus treated in May will be united by August.

The method of inarching is, bend the best-situated young branch of the tree or shrub to be propagated, to the stock to be grafted, and having determined on the part at which most conveniently to fix the shoot, cut the bark of that part of the shoot off, with nearly half the wood (not to touch the pith) to the length of about three inches for a strong branch, or less for a weaker. Then cut exactly so much of the bark and branch of the stock off, as will receive the cut part of the branch or shoot, so as to bring bark and bark in contact in every part; and if the contrivance of lipping is used, it will secure them better together. Bind and clay, and if in open ground, fix a stake to tie the work so that the wind may have no power over it; a tie also to a neat stick may be proper for those inarched in pots, &c.

Budding, or *inoculation*, though here last mentioned, is the most considerable mode of propagation. Apricots, peaches, and nectarines, are always propagated this way, and plums and cherries may be. Pears are sometimes budded, and apples have been, but the success is uncertain. Not only fruit, but forest, and ornamental trees and shrubs are inoculated. The branches also of trees as well as stems are sometimes budded, which is best done on two-years wood, though it may be on both younger and older.

Inoculation begins as soon as good shoots with good eyes, of the present year can be had, so that the season may be reckoned from mid-June to mid-August; but about old Midsummer, or rather after, is the usual and best time for the work; it should be done in a morning or evening (the latter rather best), except the day is cloudy, when any part of it will do.

Apricots being first ready, the budding season begins with them. The stocks to be used are those of the plum (raised from stones or suckers) when half an inch thick, a little under or over, and the operation is to take place from four to eight inches from the ground.

Peaches and nectarines are propagated on the same sort of stocks; but if the plum stock is first budded with an apricot (very low), and when of proper size budded with a peach, and especially a nectarine, the advantage is reckoned that it takes best so, and comes to a better bearing, producing an improved fruit, and particularly the red Roman nectarine. Apricots may be expected to be less luxuriant by double-budding, in which case the first bud should be of the Brussels sort.

Plums and cherries may be inoculated on sucker stocks of any kind; yet, if a tree is required, (as for standards), stocks raised from stones are best; *i. e.* plums on plums, and cherries on cherries, though they will take upon each other.

Pears, if for standards, should be inoculated on pear stocks, and on those raised from seed, rather than suckers; but if for dwarfs, quince stocks may be best used, to keep the trees from growing off too fast, and so getting soon too big for their allotted space; white-thorn stocks are sometimes used with the same view, but the fruit gets stony. Stocks for budding dwarfs should be three years old; but for standards four or more.

Though the longer inoculation is deferred, the riper the shoots will be for furnishing buds; yet there is this advantage in beginning as early as may be, that if the budding appears not to have taken, the work may be done again before the season is out. Or, to ensure success, two buds may be inserted in the same stock (but not in a direction under one another), and if both fail this year, the stocks may do again the next, as the heads in grafting by inoculation are not to be cut off till the spring following, because the inserted buds do not push off till then.

Let the scions to procure buds for inoculation, be taken only from the outside branches of healthy and fruitful trees. If early budding is attempted, it will be proper to cut off some spare shoot (not fit for the purpose) to try first whether the bark will yet readily part from the wood.

The season being right, and the scions at hand, have a sharp narrow-bladed knife, and neat tough wet bass. Keep the buds, as much as may be, from sun and wind: they must not be taken from the upper part of the scions, as the bark and buds there are too raw. If scions or buds are brought from any distance, they should be conveyed in damp moss or grass, and never kept above a day and night, but the sooner they are used the better.

Before the buds are prepared, get the stock ready to receive them, by taking off lateral shoots, leaving an uncut single stem. At the part fixed on for the inoculation (which should be smooth, and rather on the north side) cut the bark through to the wood in form thus, T, the cross and the down slit being of the length necessary to take in the bud, which may be cut with from one to two inches of bark; putting the point of a knife (or some instrument rather not of iron or steel) into the top of the down cut of the stock, raise the bark all the way to the bottom, so that it will just receive the bud easily. There are knives made on purpose for budding, with flat ivory hafts.

To procure proper buds, put your knife in (suppose) about three-fourths of an inch above the eye, and with a slope downwards cut the scion half through, then do it at the same distance below the eye, and sloping it upwards cut up the middle of the wood, till the knife meets the upper incision, so the eye, or bud, will be directly in the middle.

The next step is, to separate the wood from the bark, which is to be done thus: with your nail, or the point of a knife, loosen the bark at the top, and strip it from the wood; or rather with a swan or large goose quill, made in the form of an apple-scoop (having a regular smooth edge) push it down between the bark and wood, pressing it against the wood.

Examine the inside of the bark, and if there is a cavity just behind the eye or bud, it is good for nothing, and another must be procured; for the cavity shows, that the root of the bud is with the wood, instead of being with the bark.

The leaf that grows by the eye is to be cut down to near its footstalk, so as to leave only a little bit of it to hold the bud by, while inserting it in the stock.

See that the bark of the stock is loosened a proper length and breadth, and if, when the bud is put in, it should prove a little too long, cut the spare part off; so that the top of the bud being squared, falls in straight with the cross cut of the stock. Thus fixed, bind it moderately tight in its place with the wet bass, beginning at the bottom, and passing by the bud, go on till the top, or rather above it. Care must be taken that the bud is not hurt, and it is to be left only just starting out between the bass.

If the buds have taken, it will be seen in about three weeks or a month, by their appearing fresh and plump. As often as any shoots appear before the budding, cut them off, and also some of the shoots above, if there are many of them: for it is not proper that an inoculated stock should have a large head. In a month loosen the bandage, by taking it off, and putting it on gently again for another month.

In March, cut the head of the stock off with a keen knife, close behind the budding, in a sloping direction; some leave three or four inches of the stock above the bud till the following spring, and it will serve to tie the new shoot to, in order to keep it to a proper erect direction. Suffer no shoots from the stock, but rub the buds off as soon as they appear. It may be of use to shade inoculated buds a few days by a leaf, or a bit of paper.

GRAIN, a small weight, the twentieth part of a scruple in apothecaries' weight, and the twenty-fourth of a pennyweight troy. A grain weight of gold bullion is worth about two-pence, and that of silver about half a farthing.

GRAIN also denotes the component particles of stones and metals, the veins of wood, &c. Hence cross-grained, or against the grain, is contrary to the fibres of wood, &c.

GRAINING-BOARD, among curriers, an instrument called also a pummel, used to give a grain to their leather.

GRAMMAR, the art of speaking and writing any language with propriety. It is usually divided into four parts, orthography, etymology, syntax, and prosody.

GRALLÆ, in ornithology, is an order of birds, in the Linnean system, which have a beak a little cylindric, rather blunt, and bare of feathers at the base. The tongue is entire and fleshy, pointed at the end, and beset with bristles. The legs are without feathers, above the knees. This order includes 20 genera, viz. the phænicopterus, platalea, palamedea, mycteria, tantalus, ardea, corrira, recurvirostra, scolopax, tringa, fulica, parra, vaginalis, psophia, cancroma, rallus, scopus, glareola, hæmatopus, and charadrius.

GRANADIER, a soldier armed with a sword, a firelock, a bayonet, and a pouch full of hand-granadoes. They wear high caps, are generally the tallest and briskest fellows, and are always the first upon all attacks. Every battalion of foot has generally a company of grenadiers belonging to it, or else four or five grenadiers belong to each company of the battalion; which, on occasion, are drawn out, and form a company of themselves. These always take the right of the battalion.

GRANADO, a hollow ball or shell, of iron or other metal, about two inches and a half in diameter; which being filled with fine powder, is set on fire by means of a small fusee fastened to the touch-hole, made of the same composition as that of a bomb; as soon as the fire enters the shell, it bursts into many pieces, much to the damage of all that stand near.

GRANARY. See HUSBANDRY.

GRANATITE, a stone found in Galicia in Spain, Brittany in France, and at St. Gothard. It is always crystallised in a very peculiar form; two six-sided prisms intersect each other, either at right angles or obliquely. Hence the name cross-stone, by which it was known in France and Spain. Mr. Hauy has proved, in a very ingenious manner, that the primitive form of the granatite is a rectangular prism, whose bases are rhombs, with angles of $129\frac{2}{10}$ and $50\frac{2}{10}$; and that the height of the prism is to the greater diagonal of a rhomb as 1 to 6; and that its integrant molecules are triangular prisms, similar to what would be obtained by cutting the primitive crystal in two, by a plane passing vertically through the shorter diagonal of the rhomboidal base. From this structure he has demonstrated the law of the formation of the cruciform varieties. The colour of granatite is greyish or reddish brown. Specific gravity 3.2861. Usually opaque. Glassy or greasy. Infusible before the blowpipe. Two specimens, analysed by Vauquelin, gave the following constituents:

From Brittany,
44.00 alumina
33.00 silica
13.00 oxide of iron
3.84 lime
1.00 oxide of manganese.

94.84

From St. Gothard,
47.06 alumina
30.59 silica
15.30 oxide of iron
3.00 lime

95.95

GRAND DAYS, are those days in the several terms, which are solemnly kept in the inns of the court of chancery, viz. Candlemas-day, Ascension-day, St. John the Baptist, and all Saint's-day.

GRAND JURY, is the jury which find bills of indictment before justices of peace and gaol-delivery, or of

oyer and terminer, &c. against any offenders that may be tried for the fact. See JURY.

GRANITE, a genus of stones of the order of petræ, belonging to the class of saxa. The principal constituent parts of this stone are feltspar or rhombic quartz, mica, and quartz. These ingredients constitute the hardest sort of granite, and that most anciently known. That into which schoerl enters is more subject to decomposition. They never have any particular texture or regular form, but consist of enormous shapeless masses extremely hard. In the finer granites the quartz is transparent; in others generally white or grey, violet, or brown. The feltspar is generally the most copious ingredient, and of a white, yellow, red, black, or brown colour. The mica is also grey, brown, yellow, green, red, violet, or black; and commonly the least copious. The schoerl is generally black, and abounds in the granites that contain it. Hence the colour of the granites depends principally on that of the spar or schoerl. The red granites consist commonly of white quartz, red feltspar, and grey mica; the grey ones of white quartz grey or violet feltspar, and black mica. The black granites commonly contain schoerl instead of feltspar; and the green usually contain green quartz.

On exposing granite to the flame of a blowpipe, the component ingredients separate from one another. Mr. Gerhard having melted some in a crucible, found the feltspar run into a transparent glass; below it the mica lay in form of a black slag, the quartz remaining unaltered. It melted somewhat better when all the three were powdered and mixed together; though even then the quartz was still discernible by a magnifying-glass. Hence we may explain the reason why grains of a white colour are sometimes found in volcanic lavas. The mixture of mica prevents the silex or quartz from splitting or cracking; and hence its infusibility and use in furnace-building.

Granites are seldom slated or laminated. In those which are of a close texture, the quartz and schoerl predominate. They take a good polish; for which reason the Egyptians formerly, and Italians still work them into larger pieces of ornamental architecture, for which they are extremely fit, as not being liable to decay in the air. Farber, in his letters from Italy, mentions a kind of stone named granitone, composed of feltspar and mica: a substance of this kind, which moulders in the air, is found in Finland; which is said to contain nitre, and sometimes common salt. In that country it is called rapakiri. Wallerius describes 18 species of granites, besides many others akin to this genus. Those particularly in use are,

1. The hard white granite, with black spots, commonly called moor-stone. This is a very valuable kind, consisting of a beautiful congeries of very variously constructed and differently coloured particles, not diffused among or running into one another, but each pure and distinct, though firmly adhering to which ever of the others it comes in contact with, and forming a very firm mass. It is much used in London for the steps of public buildings, and other occasions where great strength and hardness are required.

2. The hard red granite variegated with black and white, are common in Egypt and Arabia.

3. The pale-whitish granite, variegated with black and yellow. This is sometimes found in strata, but more frequently in loose nodules, and is used for paving the streets.

Some of these kinds of stones are found in almost every country, and in many places they are found of immense size. The largest mass of this kind in the known world, lying as an unconnected stone, is found near the Cape of Good Hope in Africa, and of which we have the following description in the Philosoph. Transact. vol. 68, given by Mr. Anderson, in a letter to sir John Pringle: "The stone is so remarkable, that it is called by the people here, the tower of Babel, and by some the pearl diamond. It either takes the last name from a place near which it is situated, or it gives name to the tract of cultivated land called the Pearl. It lies upon the top of a ridge of low hills, beyond a large plain, at the distance of about thirty miles from the Cape Town; beyond which, at a little distance, is a range of hills of a much greater height. It is of an oblong shape, and lies north and south. The south end is highest: the east and west sides are steep and high; but the top is rounded, and slopes away gradually to the north end, so that you can ascend it that way, and enjoy a most extensive prospect of the whole country. I could not precisely determine its circumference, but it took us about half an hour to walk round it; and by making every allowance for the rugged way, and stopping a little, I think the most moderate computation must make it exceed half a mile. The same difficulty occurred with respect to knowing its height; but I think that at the south end it is nearly equal to half its length; or, were I to compare it to an object you are acquainted with, I should say it equalled the dome of St. Paul's church." He adds, "I am uncertain whether it ought to be considered as the top of the hill, or a detached stone, because there is no positive proof of either, unless we were to dig about its base." A part of this stone being examined by sir William Hamilton, he determined it to be a granite, and of the same nature with the tops of some of the Alps; and supposes both of them to have been elevated by volcanic explosions.

GRANITELLO, a genus of stones of the order petræ, belonging to the class of saxa. There are two species,

1. That composed of distinct particles, found in several of the mountainous parts of Sweden. In some of these there is a predominance of quartzose particles, in others of micaceous; in which last case the stone is slaty, and easily split.

2. Granitello composed of convoluted particles. This is met with of different colours, as whitish-grey, greenish, and reddish. Both these kinds of stone are used in building furnaces, on account of the powerful resistance they make to the fire; but the latter is preferable to the other, on account of its containing a little of a refractory clayish substance. It is likewise of great use in mills, where the fellow is a coarse sandstone.

GRANT, in law, a conveyance in writing of such things as cannot pass or be conveyed by word only; such are rents, reversions, services, advowsons in gross, tithes, &c.

The person making such a conveyance is called the grantor, and he to whom the grant is made the grantee.

A grant has usually the words *give and grant*, &c. which in a deed of what lies in grant, will amount either to a gift, grant, feoffment, or release, &c. and accordingly may be pleaded: though to every good grant it is requisite that there be a grantor, or person able to give; a grantee, capable of the thing granted; something granted, as grantable; that it be done in the manner the law requires; and that there be an agreement to, and an acceptance of, the grant by him to whom made, &c.

When persons non sanæ memoriæ make grants, they may be good as to themselves, though voidable by their heirs, &c. and notwithstanding infants and feme-coverts are prohibited by law to be grantors, yet they may be grantees: however an infant, when at his full age, may disagree to his grant, and the husband to that made to his wife. All grants are expounded according to the substance of the deed in a reasonable sense, and agreeable to the intent of the parties. In case a person grants a rent-charge out of land, and he has then nothing in the same, admitting he afterwards purchases the land, nevertheless the grant is void. And the law does not allow of grants of titles only, or imperfect interest, or of things that are merely future. Likewise grants may be void on account of uncertainty, impossibility, being against the law, &c.

Grant *of the king* is good for himself and his successors, though they are not named therein; but the king may not grant away an estate-tail in the crown.

A grant tending to a monopoly cannot be made by the king, to the detriment of the interest and liberty of the subject; neither can the king make a grant non obstante any statute, made or to be made; for if he does, any subsequent statute prohibiting what is granted will be a revocation of the grant: yet there may be a non obstante to a former grant made by the king, where he has been deceived in such grant, as where it contains more than what was intended to be granted, or there is any deceit in the consideration, &c. by which the first grant becomes void.

GRANULATION. See Chemistry.

GRAPE. See Vitis.

Grape-shot, in artillery, is a combination of small shot, put into a thick canvas bag, and corded strongly together, so as to form a kind of cylinder, whose diameter is equal to that of the ball adapted to the cannon. The number of shot in a grape varies according to the service, or size of the guns: in sea-service nine is always the number; but by land it is increased to any number or size, from an ounce and a quarter in weight to three or four pounds. In the sea-service the bottoms and pins are made of iron, whereas those used by land are of wood.

GRAPHIC, *gold ore*. See Tellurium.

GRAPHITES, in mineralogy, a mineral consisting principally of carbon with a little iron, and generally a little silica or alumina; when pure it burns with a reddish flame, emitting beautiful sparks, and a smell of sulphur, and leaving a little residuum. Its colour is dark iron-grey, or brownish black; when cut, blueish grey. Opaque: structure slaty. Texture fine-grained. Brittle. Specific gravity from 1.987 to 2.089; after being soaked in water 2.15; after being heated 2.3. Feels somewhat greasy, stains the fingers, and marks strongly. In modern chemistry it is denominated carburet of iron; and one of the species is plumbago; the use of which, when manufactured into pencils, is known to every one. When pure it consists of,

90 carbon
10 iron
——
100.

GRAPHOMETER, a mathematical instrument, otherwise called a semicircle, the use of which is to observe any angle, whose vertex is at the centre of the instrument in any plane (though it is most commonly horizontal, or nearly so), and to find how many degrees it contains.

The graphometer (Pl. LXIV. Mis. fig. 108) is a graduated semicircle ABC, made of wood, brass, or the like, and so fixed on a fulcrum GH, by means of a brass ball and socket, that it easily turns about, and retains any situation. It has two sights fixed on its diameter AC, and at the centre there are commonly a magnetical needle and compass in a box. There is likewise a moveable ruler or index, ED, with two sights P, P; which turns round the centre, and retains any situation given it.

To measure by this instrument any angle ACB (fig. 109), in any plane, and comprehended between the right lines AC and BC, drawn from two points A and B, to the place of station C. Let the graphometer be placed at C, supported by its fulcrum; and let the immoveable sights on the diameter of the instrument DE, be directed towards the point A; and likewise while the instrument remains immoveable, let the sights of the ruler FG, which is moveable about the centre C, be directed to the point B. Now it is evident that the moveable ruler cuts off an arch DG, which is the measure of the angle ACB, sought. Moreover, by the same method, the inclination of DE, or FG, may be observed with the meridian line, which is pointed out by the magnetic needle inclosed in the box, and moveable about the centre of the instrument.

GRAPNELS, a sort of anchors with four flooks, serving for boats to ride by.

There is also a kind called fire and chain-grapnels, made with four-barbed claws instead of flooks, and used to catch hold of the enemies' rigging, or any other part, in order for boarding them. See Plate LXIV. Miscel. fig. 110.

GRASS. See Botany. For the culture of the different sorts of grass, see Husbandry.

GRASSHOPPER, in zoology. See Gryllus.

GRATINGS, in a ship, a kind of lattice-work formed of ledges and battens, the square holes of which being three or four inches wide, are for the current footing of men over hatchways, to give air below, and vent for the smoke in an engagement.

GRATIOLA, *hedge-hyssop*, a genus of the monogynia order, in the diandria class of plants. The corolla is irregular; there are two barren stamina; the capsule is bilocular; the calyx has seven leaves, with the two exterior ones patulous. There are 12 species; the most remarkable of which is the officinalis, or common hedge-hyssop. This grows naturally in the Alps and other mountainous parts of Europe. It has a thick, fleshy,

fibrous, creeping root, which propagates very much, when planted in a proper soil and situation. From this arise several upright square stalks; with narrow spear-shaped leaves, placed opposite. The flowers are produced on the side of the stalks at each joint; they are shaped like those of the fox-glove, but are small, and of a pale-yellowish colour. This herb has an emetic and purgative virtue; to answer which intentions it was formerly used by the common people in England, but was never much prescribed by the physicians, and at last fell totally into disuse. Of late, however, it has been the subject of a dissertation by Dr. James Kostrzewski, of Warsaw, in Poland, who gives some remarkable accounts of its effects in mania and obstinate venereal cases. It was given in powder, or in extract, to the quantity of half a drachm of the first, and a whole drachm of the second, at each dose.

GRAVE, in music, is applied to a sound which is of a low or deep tone.

GRAVEL, in natural history and gardening, a congeries of pebbles, which, mixed with a stiff loam, makes lasting and elegant walks; an ornament peculiar to our gardens, and which gives them the advantage over those of all other nations.

GRAVEL. See MEDICINE.

GRAVIMETER, the name given by M. Guyton to an instrument for measuring specific gravities: he adopts this name rather than either areometer or hydrometer, because these latter terms are grounded upon the supposition that a fluid is always the thing weighed; whereas, with regard to solids, the liquid is the known term of comparison to which the unknown weight is referred.

Guyton's gravimeter is executed in glass, and is of a cylindric form, being that which requires the smallest quantity of fluid, and is on that account preferable, except so far as it is necessary to deviate for the security of a vertical position. It carries two basins; one of them superior, at the extremity of a thin stem, towards the middle of which the fixed point of immersion is marked. The other, or lower basin, terminates in a point; it contains the balls, and is attached to the cylinder by two branches. The moveable suspension by means of a hook has the inconvenience of shortening the lever which is to secure the vertical position.

The cylinder is 22 millimetres (0.71 inch) in diameter; and 21 centimetres (6.85 inches) in length. It carries in the upper basin an additional constant weight of five grammes (115 grains.) These dimensions might be increased so as to render it capable of receiving a much more considerable weight; but this is unnecessary. M. Guyton has added a piece which he calls the plongeur, because in fact it is placed in the lower basin when used, and is consequently entirely immersed in the fluid. It is a bulb of glass loaded with a sufficient quantity of mercury, in order that its total weight may be equal to the constant additional weight, added to the weight of the volume of water displaced by this piece. It will be readily understood that the weight being determined at the same temperature at which the instrument was originally adjusted, it will sink to the same mark on the stem; whether it is loaded with a constant additional weight in the upper basin, or whether the effect of this weight be produced by the additional piece in the lower dish. From this explanation there will be no difficulty in seeing how this instrument may be adapted to every case in practice.

It may be used, 1. for solids. The only condition will be, that the absolute weight of the body to be examined shall be rather less than the constant additional weight, which in this instrument is five grammes, or 115 grains.

2. For liquids of less specific gravity than water the instrument, without the additional weight above-mentioned, weighs about two decagrammes (459 grains) in the dimensions before laid down. It would be easy to limit its weight to the utmost accuracy. We have therefore the range of one-fifth of buoyancy, and consequently the means of ascertaining all the intermediate densities from water to the most highly rectified spirit of wine, which is known to bear in this respect the ratio of eight to ten with regard to water.

3. When liquids of greater specific gravity than water are to be tried, the constant weight being applied below, by means of the additional piece, which weighs about six grammes (138 grains,) the instrument can receive in the upper basin more than four times the additional weight, without losing the equilibrium of its vertical position. In this state it is capable of showing the specific gravity of the most concentrated acids.

4. It possesses another property, namely, that it may be used as a balance to determine the absolute weight of such bodies as do not exceed its additional load.

5. Lastly, the purity of the water being known, it will indicate the degrees of rarefaction and condensation in proportion to its own bulk.

This instrument may be readily constructed by any workman in glass. The additional piece for the lower basin will require some attention to make it perfectly agree with the constant upper weight, as to the immersion of the instrument. But this object may, by careful adjustment, be ascertained with the utmost certainty and accuracy. The bulb of glass is for this purpose drawn out to a fine point; a sufficient quantity of mercury is then introduced to sink it, and the aperture closed with a little piece of wax. The bulb being then placed in the lower basin of the instrument, the upper basin is to be loaded until the mark on the stem becomes accurately coincident with the surface of the water. The sum of the weights added above is precisely equal to that of the quantity of mercury necessary to be added to that in the glass bulb; which done, nothing more is needed than to seal the point by fusion, taking care not to change its bulk.

The whole is rendered portable by means of a case in which all the delicate parts are secured from pressure, and the heavier parts supported in such a manner as to resist the excess of motion they are capable of acquiring by virtue of their mass. This last circumstance is frequently overlooked by such workmen as are employed in the package of instruments; whence it necessarily follows, that some strain or fracture must be produced when matters of very unequal density are exposed to receive a common impulse.

To find the specific gravity of any solid by the gravimeter, observe this rule: "From the weight in the upper dish, when the instrument is properly immersed in the unknown fluid, take the weight which is placed with the

body in the same scale at the like adjustment. The remainder is the absolute weight of the solid. Multiply this by the specific gravity of the fluid, and reserve the product. From the additional weight when the body is placed in the lower basin, take the weight when it was placed in the upper. The remainder will be the loss of weight by immersion. Divide the reserved product by the loss by immersion, and the quotient will be the specific gravity of the solid with regard to distilled water at the standard temperature and pressure."

To find the specific gravity of a fluid proceed thus: "To the weight of the gravimeter add the weight required in the upper basin to sink it in the unknown fluid. Again, to the weight of the gravimeter add the weight required in the same manner to sink it in distilled water. Divide the first sum by the latter, and the quotient will be the specific gravity of the fluid in question." See SPECIFIC GRAVITY, HYDROSTATICS, and HYDROMETER.

GRAVING, in the sea language, is bringing a ship aground, and then burning off with furze, reed, or broom, all the filth and foulness that sticks to her bottom without board, in order to pay her anew.

GRAVITATION. See ATTRACTION, and GRAVITY.

GRAVITATION, *laws of*, are as follows: 1. It is common to all bodies, and mutual between them. 2. It is proportional to the quantity of matter in bodies. 3. It is exerted every way from the centre of the attracting body in right-lined directions. 4. It decreases as the squares of the distances increase: thus, if a body at A on the earth's surface, distant one semidiameter from the centre C, weighs 36.00 pounds, it will, at the distance of 2, 3, 4, 5, 6, semidiameters, weigh 9.00, 4.00, 2.25, 1.45, 1.00 pounds, which numbers decrease as the squares of the distances increase. The truth of this proposition is not to be had from experiments; the utmost distance we convey bodies to, from the surface of the earth, bearing so small a proportion to their distance from its centre, but is sufficiently clear from the motions observed by the heavenly bodies. Hence we learn, that all bodies have gravity, or are heavy, and that there is no such thing as absolute levity in nature; and by the second law, the gravitation of all bodies is proportional to the quantity of matter they contain: and hence, since bodies of equal bulk are found to have unequal quantities of matter, it evidently follows, that a vacuum, or solid void of matter, must necessarily exist, and that an absolute plenum is a doctrine unphilosophical, and equally false and absurd.

Also from the third law it follows, that all bodies descending freely by their gravity, tend towards the earth in right lines perpendicular to its surface, and with equal velocities, abating for the resistance of the air; as is evident from the second law above.

Again, since the gravitation is always as the quantity of matter, and inversely as the square of the distance, it follows, that were the internal parts of the earth a perfect void, or hollow concavity, a body placed any where therein would be absolutely light, or void of gravity; but supposing the earth a solid body throughout, the gravitation from the surface to the centre will decrease with the distance, or it will be directly proportional to the distance from the centre.

Gravitation being found by many experiments and observations to affect all the matter of bodies equally, we have hence more reason, says Mr. Maclurin, to conclude its universality, since it appears to be a power that acts not only at the surfaces of bodies, and on such bodies as are removed at a distance from them, but to penetrate into their substances, and into that of all other bodies, even to their centres, to affect their internal parts with the same force as the external, to be obstructed in its action by no intervening body or obstacle, and to admit of no kind of variation in the same matter, but from its different distances only from that to which it gravitates.

This action of gravity on bodies arises from its action on their parts, and is the aggregate of these actions; so the gravitations of bodies must arise from the gravity of all their particles towards each other. The weight of a body towards the earth arises from the gravity of the parts of that body: the gravity of a mountain towards the earth arises from the gravitation of all the parts of the mountain towards it; the gravitation of the northern hemisphere towards the southern arises from the gravitation of all its parts towards it; and if we suppose the earth divided into two unequal segments, the gravitation of the greater towards the lesser arises from the gravitation of all the parts of the greater towards the lesser. In the same manner the gravity of the whole earth, one particle being excepted, toward that particle, must arise from the quantity of gravitation of all the other particles of the earth towards that particle; every particle, therefore, of the earth gravitates towards every other particle: and for the same reason every particle in the solar system gravitates towards every other particle in it.

GRAVITY, in physiology, the natural tendency of bodies towards a centre.

Gravity may be distinguished into particular and general.

Particular GRAVITY, is that which respects the earth, or by which bodies descend, or tend towards the centre of the earth; the phenomena or properties of which are as follow:

1. All circumterrestrial bodies tend towards a point, which is either accurately or very nearly the centre of magnitude of the terraqueous globe. Not that it is meant that there is really any virtue or charm in the point called the centre, by which it attracts bodies; but because this is the result of the gravitation of bodies towards all the parts of which the earth consists.

2. This point or centre is fixed within the earth, or at least has been so considered as far as any authentic history reaches. For a consequence of its shifting, though ever so little, would be the overflowing of the low lands on that side of the globe towards which it should approach. Dr. Halley suggests, that it would well account for the universal deluge, to have the centre of gravitation removed for a time towards the middle of the then inhabited world; for the change of its place but the 2000th part of the radius of the earth, or about two miles, would be sufficient to lay the tops of the highest hills under water.

3. In all places equidistant from the centre of the earth, the force of gravity is nearly equal. Indeed all parts of the earth's surface are not at equal distances from the centre, because the equatorial parts are higher than the polar parts by about 17 miles; as has been pro-

ved by the necessity of making the pendulum shorter in those places, before it will swing seconds. In the New Petersburgh Transactions, vol. 6 and 7, M. Krafft gives a formula for the proportion of gravity in different latitudes on the earth's surface, which is this:

$$y = (1 + 0.0052848 \text{ sine } ^2\lambda)\, g;$$

where g denotes the gravity at the equator, and y the gravity under any other latitude λ.

4. Gravity equally affects all bodies, without regard either to their bulk, figure, or matter: so that, abstracting from the resistance of the medium, the most compact and loose, the greatest and smallest bodies, would all descend through an equal space in the same time; as appears from the quick descent of very light bodies in an exhausted receiver. The space which bodies do actually fall in vacuo, is $16\frac{1}{12}$ feet in the first second of time, in the latitude of London; and for other times, either greater or less than that, the spaces descended from rest are directly proportional to the squares of the times, while the falling body is not far from the earth's surface.

5. This power is the greatest at the earth's surface, whence it decreases both upwards and downwards, but not both ways in the same proportion; for upwards the force of gravity is, as we have seen, less, or decreases, as the square of the distance from the centre, above the surface, the force would be only one-fourth of what it is at the surface; but below the surface the power decreases in such a manner, that its intensity is in the direct ratio of the distance from the centre; so that at the distance of half a semidiameter from the centre, the force would be but half what it is at the surface; at one-third of a semidiameter the force would be one-third, and so on.

6. As all bodies gravitate towards the earth, so does the earth equally gravitate towards all bodies; as well as all bodies towards particular parts of the earth, as hills, &c. which has been proved by the attraction a hill has upon a plumb-line, insensibly drawing it aside. Hence the gravitating force of entire bodies consists of that of all their parts: for by adding or taking away any part of the matter of a body, its gravity is increased or decreased in the proportion of the quantity of such proportion to the whole mass. Hence also the gravitating powers of bodies, at the same distance from the centre, are proportional to the quantities of matter in the bodies.

General or universal GRAVITY, is that by which all the planets tend to one another, and indeed by which all the bodies and particles of matter in the universe tend towards one another.

The existence of the same principle of gravitation in the superior regions of the heavens, as on the earth, is one of the great discoveries of Newton, who made the proof of it as easy as that on the earth. At first it would seem that this was only conjecture with him: he observed that all bodies near the earth, and in its atmosphere, had the property of tending directly towards it; he soon conjectured that it probably extended much higher than any distance to which we could reach, or make experiments; and so on, from one distance to another, till he at length saw no reason why it might not extend as far as to the moon, by means of which she might be retained in her orbit as a stone in a sling is retained by the hand; and if so, he next inferred, why might not a similar principle exist in the other great bodies in the universe, the sun and all the other planets, both primary and secondary, which might all be retained in their orbits, and perform their revolutions, by means of the same universal principle of gravitation.

These conjectures he soon realized and verified by mathematical proofs. Kepler had found out, by contemplating the motions of the planets about the sun, that the area described by a line connecting the sun and planet, as this revolved in its orbit, was always proportional to the time of its description; or that it described equal areas in equal times, in whatever part of its orbit the planet might be, moving always so much the quicker as its distance from the sun was less. And it is also found that the satellites, or secondary planets, respect the same law in revolving about their primaries. But it was soon proved by Newton, that all bodies moving in any curve line described on a plane, and which, by radii drawn to any certain point, describe areas about the point proportional to the times, are impelled or acted on by some power tending towards that point. Consequently the power by which all these planets revolve, and are retained in their orbits, is directed to the centre about which they move, viz. the primary planets to the sun, and the satellites to their several primaries.

Again, Newton demonstrated, that if several bodies revolve with an equable motion in several circles about the same centre, and that if the squares of their periodical times are in the same proportion as the cubes of their distances from the common centre, then the centripetal forces of the revolving bodies, by which they tend to their central body, will be in the reciprocal or inverse ratio of the squares of the distances. Or if bodies revolve in orbits approaching to circles, and the apses of those orbits are at rest, then also the centripetal forces of the revolving bodies will be reciprocally proportional to the squares of the distances. But it had been agreed on by the astronomers, and particularly Kepler, that both these cases obtain in all the planets. And therefore he inferred, that the centripetal forces of all the planets are reciprocally proportional to the squares of the distances from the centres of their orbits.

Upon the whole it appears, that the planets are retained in their orbits by some power which is continually acting upon them: that this power is directed towards the centre of their orbits: that the intensity or efficacy of this power increases upon an approach towards the centre, and diminishes on receding from the same, and that in the reciprocal duplicate ratio of the distances: and that, by comparing this centripetal force of the planets with the force of gravity on the earth, they are found to be perfectly alike, as may easily be shown in various instances. For example, in the case of the moon. The rectilinear spaces described in any given time by a falling body, urged by any powers, reckoning from the beginning of its descent, are proportional to those powers. Consequently the centripetal force of the moon revolving in her orbit, will be to the force of gravity on the surface of the earth, as the space which the moon would describe in falling during any small time, by her centripetal force towards the earth, if she had no circular motion at all, to the space of a body near the earth would describe in falling by its gravity towards the same.

Now by an easy calculation of those two spaces, it ap-

pears that the former force is to the latter, as the square of the semidiameter of the earth is to the square of that of the moon's orbit. The moon's centripetal force therefore is equal to the force of gravity; and consequently these forces are not different, but they are one and the same: for if they were different, bodies acted on by the two powers conjointly would fall towards the earth with a velocity double to that arising from the sole power of gravity.

It is evident therefore that the moon's centripetal force, by which she is retained in her orbit, and prevented from running off in tangents, is the very power of gravity of the earth extended thither. See Newton's Princip. lib. 1, prop. 45, and lib. 3, prop. 3; where the numeral calculation may be seen in full length.

The moon therefore gravitates towards the earth, and reciprocally the earth towards the moon. And this is also farther confirmed by the phenomena of the tides.

The like reasoning may also be applied to the planets. For as the revolutions of the primary planets round the sun, and those of the satellites of Jupiter and Saturn round their primaries, are phenomena of the same kind with the revolution of the moon about the earth; and as the centripetal powers of the primary are directed towards the centre of the sun, and those of the satellites towards the centres of the primaries; and, lastly, as all these powers are reciprocally as the squares of the distances from the centres, it may safely be concluded that the power and cause are the same in all.

As the moon, therefore, gravitates towards the earth, and the earth towards the moon; so do all the secondaries to their primaries, and these to their secondaries; and so also do the primaries to the sun, and the sun to the primaries. Newton's Princip. lib. 3, prop. 4, 5, 6; Greg. Astron. lib. 1, sect. 7, prop. 46 and 47.

The laws of universal gravity are the same as those of bodies gravitating towards the earth, before laid down.

Cause of gravity. Various theories have been advanced by the philosophers of different ages to account for this grand principle of gravitation. The ancients, who were only acquainted with particular gravity, or the tendency of sublunar bodies towards the earth, aimed no farther than to establish a system that might answer the more obvious phenomena of it. Some hints, however, are found concerning the gravitation of celestial bodies in the account given of the doctrine of Thales and his successors; and it would seem that Pythagoras was still better acquainted with it, and which it is supposed he had in view in what he taught concerning the harmony of the spheres.

Aristotle and the peripatetics content themselves with referring gravity or weight to a native inclination in heavy bodies to be in their proper place or sphere, the centre of the earth. And Copernicus ascribes it to an innate principle in all parts of matter, by which, when separated from their wholes, they endeavour to return to them again the nearest way.

Kepler, in his preface to the Commentaries concerning the planet Mars, speaks of gravity as of a power that was mutual between bodies; and says that the earth and moon tend towards each other, and would meet in a point so many times nearer to the earth than to the moon, as the earth is greater than the moon, if the motions did not hinder it. He adds that the tides arise from the gravity of the waters towards the moon. To him we also owe the important discovery of the analogy between the distances of the several planets from the sun, and the periods in which they complete their revolutions, viz. that the squares of their periodic times are always in the same proportion as the cubes of their mean distances from the sun. However, Kepler, Gassendi, Gilbert, and others, ascribe gravity to a certain magnetic attraction of the earth; conceiving the earth to be one great magnet continually emitting effluvia, which take hold of all bodies, and draw them towards the earth. But this is inconsistent with the several phenomena.

Des Cartes and his followers, Rohault, &c. attribute gravity to an external impulse or trusion of some subtle matter. By the rotation of the earth, say they, all the parts and appendages of it necessarily endeavour to recede from the centre of rotation; but whence they cannot all actually recede, as there is no vacuum or space to receive them. But this hypothesis, founded on the supposition of a plenum, is overthrown by what has been since proved of the existence of a vacuum.

Dr. Halley, despairing of any satisfactory theory, chooses to have immediate recourse to the agency of the Deity. So Dr. Clarke, from a view of several properties of gravity, concludes that it is no adventitious effect of any motion, or subtile matter, but an original and general law impressed by God on all matter, and preserved in it by some efficient power penetrating the very solid and intimate substance of it; being found always proportional, not to the surfaces of bodies or corpuscles, but to their solid quantity and contents. It should therefore be no more inquired why bodies gravitate, than how they came to be first put in motion.

Gravesande, in his Introduct. ad Philos. Newton, contends, that the cause of gravity is utterly unknown; and that we are to consider it no otherwise than as a law of nature originally and immediately impressed by the Creator, without any dependance on any second law or cause at all. Of this he thinks the three following considerations sufficient proof. 1. That gravity requires the presence of the gravitating or attracting body: so that the satellites of Jupiter, for example, gravitate towards Jupiter, wherever he may be. 2. That the distance being supposed the same, the velocity with which bodies are moved by the force of gravity, depends on the quantity of matter in the attracting body; and the velocity is not changed, whatever the mass of the gravitating body may be. 3. That if gravity depends on any known law of motion, it must be some impulse from an extraneous body; so that as gravity is continual, a continual stroke must also be required. Now if there is any such matter continually striking on bodies, it must be fluid and subtile enough to penetrate the substance of all bodies: but how shall a body subtile enough to penetrate the substance of the hardest bodies, and so rare as not sensibly to hinder the motion of bodies, be able to impel vast masses towards each other with such force? How does this force increase the ratio of the mass of the body, towards which the other body is moved? Whence is it that all bodies move with the same velocity, the distance and body gravitated to being the same? Can a fluid which only acts on the surface either of the bodies themselves, or their internal particles, communicate such a

quantity of motion to bodies, which in all bodies shall exactly follow the proportion of the quantity of matter in them?

Mr. Cotes goes yet farther. Giving a view of Newton's philosophy, he asserts that gravity is to be ranked among the primary qualities of all bodies; and deemed equally essential to matter as extension, mobility, or impenetrability. Prefat. ad Newt. Princip. But Newton himself disclaims this notion; and to show that he does not take gravity to be essential to bodies, he declares his opinion of the cause; choosing to propose it by way of query, not being yet sufficiently satisfied about its experiments. Thus, after having shown that there is a medium in nature vastly more subtle than air, by whose vibrations sound is propagated, by which light communicates heat to bodies, and by the different densities of which the refraction and reflection of light are performed; he proceeds to inquire: "Is not this medium much rarer within the dense bodies of the sun, stars, planets, and comets, than in the empty celestial spaces between them? And in passing from them to greater distances, doth it not grow denser and denser perpetually, and thereby cause the gravity of those great bodies towards one another, and of their parts towards the bodies; every body endeavouring to recede from the denser parts of the medium towards the rarer?

"For if this medium be supposed rarer within the Sun's body than at its surface, and rarer there than at the hundredth part of an inch from his body, and rarer there than at the fiftieth part of an inch from his body, and rarer there than at the orb of Saturn; I see no reason why the increase of density should stop any where, and not rather be continued through all distances from the Sun at Saturn, and beyond.

"And though this increase of density may at great distances be exceeding slow; yet if the elastic force at this medium be exceeding great, it may suffice to impel bodies from the denser parts of the medium towards the rarer with all that power which we call gravity.

"And that the elastic force of this medium is exceeding great, may be gathered from the swiftness of its vibrations. Sounds move about 1140 English feet in a second of time, and in seven or eight minutes of time they move about 100 English miles: light moves from the Sun to us in about seven or eight minutes of time; which distance is about 70,000,000 English miles, supposing the horizontal parallax of the Sun to be about twelve seconds; and the vibrations, or pulses of this medium, that they may cause the alternate fits of easy transmission, and easy reflection, must be swifter than light, and by consequence above 7000000 times swifter than sounds; and therefore the elastic force of this medium, in proportion to its density, must be above 7000000×7000000 (that is, above 49,000,000,000,000) times greater than the elastic force of the air is in proportion to its density: for the velocities of the pulses of elastic mediums are in a subduplicate ratio of the elasticities and the rarities of the mediums taken together.

"As magnetism is stronger in small load-stones than in great ones, in proportion to their bulk; and gravity is stronger on the surface of small planets than those of great ones, in proportion to their bulk; and small bodies are agitated much more by electric attraction than great ones: so the smallness of the rays of light may contribute very much to the power of the agent by which they are refracted; and if any one should suppose that æther (like our air) may contain particles which endeavour to recede from one another (for I do not know what this æther is), and that its particles are exceedingly smaller than those of air, or even than those of light; the exceeding smallness of such particles may contribute to the greatness of the force by which they recede from one another, and thereby make that medium exceedingly more rare and elastic than air, and of consequence exceedingly less able to resist the motions of projectiles, and exceedingly more able to press upon gross bodies by endeavouring to expand itself." Optics, p. 325, &c.

Gravity, in mechanics, denotes the tendency of bodies towards the centre of the earth. That part of mechanics which considers the equilibrium, or motion of bodies arising from gravity or weight, is particularly called statics.

Gravity in this view is distinguished into absolute and relative.

Absolute Gravity is that with which a body descends freely and perpendicularly through an unresisting medium. See Mechanics.

Relative Gravity is that with which a body descends on an inclined plane, or through a resisting medium, or as opposed by some other resistance. See Mechanics.

Gravity, in hydrostatics. The laws of bodies gravitating in fluids make the business of hydrostatics.

Gravity is here divided into absolute and specific.

Absolute, or *true* Gravity, is the whole force with which the body tends downwards.

Specific Gravity, is the relative, comparative, or apparent gravity in any body, in respect of that of an equal bulk or magnitude of another body; denoting that gravity or weight which is peculiar to each species or kind of body, and by which it is distinguished from all other kinds.

In this sense a body is said to be specifically heavier than another, when under the same bulk it contains a greater weight than that other; and reciprocally the latter is said to be specifically lighter than the former. Thus, if there are two equal spheres, each one foot in diameter; the one of lead, and the other of wood: since the leaden one is found heavier than the wooden one, it is said to be specifically, or in specie, heavier; and the wooden one specifically lighter.

This kind of gravity is by some called relative; in opposition to absolute gravity, which increases in proportion to the quantity or mass of the body.

Laws of the specific gravity of bodies.

I. If two bodies are equal in bulk, their specific gravities are to each other as their weights, or as their densities.

II. If two bodies are of the same specific gravity or density, their absolute weights will be as their magnitudes or bulks.

III. In bodies of the same weight, the specific gravities are reciprocally as their bulks.

IV. The specific gravities of all bodies are in a ratio compounded of the direct ratio of their weights and re-

ciprocal ratio of their magnitudes. And hence again the specific gravities are as the densities.

V. The absolute gravities or weights of bodies are in the compound ratio of their specific gravities and magnitudes or bulks.

VI. The magnitudes of bodies are directly as their weights, and reciprocally as their specific gravities.

VII. A body specifically heavier than a fluid, loses as much of its weight when immersed in it, as is equal to the weight of a quantity of the fluid of the same bulk or magnitude.

Hence, since the specific gravities are as the absolute gravities under the same bulk; the specific gravity of the fluid, will be to that of the body immerged, as the part of the weight lost by the solid, is to the whole weight.

And hence the specific gravities of fluids are as the weights lost by the same solid immerged in them.

VIII. *To find the specific gravity of a fluid or of a solid.* On one arm of a balance suspend a globe of lead by a fine thread, and to the other fasten an equal weight, which may just balance it in the open air. Immerge the globe into the fluid, and observe what weight balances it then, and consequently what weight is lost, which is proportional to the specific gravity as above. And thus the proportion of the specific gravity of one fluid to another is determined by immersing the globe successively in all the fluids, and observing the weights lost it each, which will be the proportions of the specific gravities of the fluids sought.

This same operation determines also the specific gravity of the solid immerged, whether it is a globe, or of any other shape or bulk, supposing that of the fluid known. For the specific gravity of the fluid is to that of the solid, as the weight lost is to the whole weight.

Hence also may be found the specific gravity of a body that is lighter than the fluid, as follows:

IX. *To find the specific gravity of a solid that is lighter than the fluid, as water, in which it is put.* Annex to the lighter body another that is much heavier than the fluid, so that the compound mass may sink in the fluid. Weigh the heavier body and the compound mass separately, both in water and out of it; then find how much each loses in water, by subtracting its weight in water from its weight in air; and subtract the less of these remainders from the greater.

Then, As this last remainder,
Is to the weight of the light body in air,
So is the specific gravity of the fluid,
To the specific gravity of that body.

X. The specific gravities of bodies of equal weight, are reciprocally proportional to the quantities of weight lost in the same fluid. And hence is found the ratio of the specific gravities of solids, by weighing in the same fluids, masses of them that weigh equally in air, and noting the weights lost by each.

The specific gravities of many kinds of bodies, both solid and fluid, have been determined by various authors. It will be sufficient here to give those of some of the most usual bodies that have been determined with the greater certainty. The numbers in this table express the number of avoirdupoise ounces in a cubic foot of each body, that of common water being just 1000 ounces, or $62\frac{1}{2}$lb.

A TABLE

OF THE SPECIFIC GRAVITIES OF DIFFERENT BODIES, ARRANGED ALPHABETICALLY.

Metals.

Antimony, crude	4064
glass of	4946
molten	6702
Arsenic, glass of, natural	3594
molten	5763
native orpiment	5452
Bismuth, molten	9823
native	9020
ore of, in plumes	4371
Brass, cast, not hammered	8396
ditto, wiredrawn	8544
cast, common	7824
Cobalt, molten	7812
blue glass of	2441
Copper, not hammered	7788
the same wiredrawn	8878
ore of soft copper, or natural verdigr.	3572
Gold, pure, of 24 caracts, melted, but not hammered	19258
the same hammered	19362
Parisian standard, 22 car. not hammered	17486
the same hammered	17589
guinea of Geo. II.	17150
guinea of Geo. III.	17629
Spanish gold coin	17655
Holland ducats	19352
trinket standard, 20 car. not hammered	15709
the same hammered	15775
Iron, cast	7207
bar, either hardened or not	7788
Steel, neither tempered nor hardened	7833
hardened, but not tempered	7840
tempered and hardened	7818
ditto not hardened	7816
Iron, ore prismatic	7355
ditto specular	5218
ditto lenticular	5012
Lead, molten	11352
ore of, cubic	7587
ditto horned	6072
ore of black lead	6745
ditto white lead	4059
ditto ditto vitreous	6558
ditto red lead	6027
ditto saturnite	5925
Manganese, striated	4756
Molybdena	4738
Mercury, solid, or congealed	15632
fluent	13568
natural calx of	9230
precipitate per se	10871
precipitate, red	8399
brown cinnabar	10218
red cinnabar	6902
Nickel, molten	7807
ore of, called kupfernickel of Saxe	6648
kupfernickel of Bohemia	6607
Platina, crude, in grains	15602
purified, not hammered	19500
purified, hammered	20337

Platina, ditto wiredrawn	21042
ditto rolled	22069
Silver, virgin, 12 deniers, fine, not ham.	10744
ditto hammered	10511
Paris standard	10175
shilling of Geo. II.	10000
shilling of Geo. III.	10534
French coin	10408
Tin, pure Cornish, melted, not hardened	7291
the same hardened	7299
of Malacca, not hardened	7296
the same hardened	7307
ore of, red	6935
ore of, black	6901
ore of, white	6008
Tungsten	6066
Uranium	6440
Wolfram	7119
Zinc, molten	7191
Precious stones.	
Beryl, or aqua-marine, oriental	3549
ditto occidental	2723
Chrysolite, of the jewellers	2782
of Brazil	2692
Chrystal, pure rock of Madagascar	2653
of Brazil	2653
European	2655
rose-coloured	2670
yellow	2654
violet, or amethyst	2654
white amethyst	2651
Carthaginian	2657
black	2654
Diamond, white oriental	3521
rose-coloured oriental	3531
orange ditto	3550
green ditto	3524
blue ditto	3525
Brazillian	3444
yellow	3519
Emerald of Peru	2775
Garnet of Bohemia	4189
of Syria	4000
dodecaedral	4063
volcanic, 24 faces	2468
Girasol	4000
Hyacinth, common	3687
Jargon of Ceylon	4416
Quartz, crystallised	2655
in the mass	2647
brown crystallised	2647
fragile	2640
milky	2652
fat, or greasy	2646
Ruby, oriental	4283
spinell	3760
ballas	3646
Brazilian	3531
Sapphire, oriental	3994
ditto white	3991
of Puys	4077
Brazilian	3131
Spar, white sparkling	2595
Spar, red ditto	2438
green ditto	2704
blue sparkling	2693
green and white ditto	3105
transparent ditto	2564
adamantine	3873
Topaz, oriental	4011
pistachio ditto	4061
Brazilian	3536
of Saxe	3564
white ditto	3554
vermilion	4230
Silicious stones.	
Agate, oriental	2590
onyx	2638
cloudy	2625
speckled	2607
veined	2667
stained	2632
Calcedony, common	2616
transparent	2664
veined	2606
reddish	2665
blueish	2587
onyx	2615
Cornelian, pale	2630
speckled	2612
veined	2623
onyx	2623
stalactite	2598
simple	2613
Flint, white	2594
black	2582
veined	2612
Egyptian	2565
Jade, white	2950
green	2966
olive	2983
Jasper, clear green	2539
brownish green	2681
red	2661
brown	2691
yellow	2710
violet	2711
cloudy	2735
veined	2696
onyx	2816
red and yellow	2750
bloody	2628
Opal	2114
Pearl, virgin oriental	2684
Pebble, onyx	2664
of Rennes	2654
English	2609
veined	2612
stained	2587
Prasium	2581
Sardonyx, pure	2603
pale	2606
speckled	2622
veined	2595
onyx	2595
blackish	2628

Schorl, black prism. hexaedral	3364
octaedral	3226
tourmalin of Ceylon	3054
antique basaltes	2923
Brazilian emerald	3156
cruciform	3286
Stone, paving	2416
cutler's	2111
grind	2143
mill	2500
Various stones, earths, &c.	
Alabaster, oriental white	2730
ditto semitransparent	2762
yellow	2699
stained brown	2744
veined	2691
of Piedmont	2693
of Malta	2699
Spanish saline	2713
of Valencia	2638
of Malaga	2876
Amber, yellow transparent	1078
Ambergris	926
Amianthus, long	909
short,	2313
Asbestos, ripe	2578
starry	3070
Basaltes from Giants' Causeway	2864
Bitumen, of Judea	1104
Brick	2000
Chalk, Spanish	2790
coarse Briançon	2727
British	2784
Gypsum, opaque	2168
semitransparent	2306
fine ditto	2274
rhomboidal	2311
ditto 10 faces	2312
cuneiform crystallised	2306
Glass, green	2642
white	2892
bottle	2733
Leith crystal	3189
fluid	3329
Granite, red Egyptian	2654
of Balbeck	3500
Hone, white razor	2876
Lapis nephriticus	2894
lazuli	3054
hæmatites	4360
calaminaris	5000
Judaicus	2500
manati	2270
Limestone	3179
white flour	3156
green	3182
Marble, green campanian	2742
red	2724
white Cassara	2717
white Parian	2838
Pyrenean	2726
black Biscayan	2695
Brocatelle	2650

Marble, Castilian	2700
Valencian	2710
white Grenadan	2705
Siennien	2678
Roman violet	2755
African	2708
violet Italian	2858
Norwegian	2728
Siberian	2718
green Egyptian	2668
Swisserland	2714
French	2649
Obsidian stone	2348
Peat, hard	1329
Phosphorus	1714
Porcelaine, Seves	2146
Limoges	2341
China	2385
Porphyry, red	2765
green	2676
red, from Dauphiny	2793
red, from Cordone	2754
green, from ditto	2728
Pyrites, coppery	4954
feruginous cubic	3900
ditto round	4101
ditto of St. Domingo	3440
Serpentine, opaque, green Italian	2430
ditto, veined black and olive	2594
ditto, red and black	2627
semitranspar. grained	2586
ditto fibrous	3000
ditto, from Dauphiny	2669
Slate, common	2672
new	2854
black stone	2186
fresh polished	2766
Satlactite, transparent	2324
opake	2478
Stone, pumice	915
prismatic basaltes	2722
touch	2415
Siberian blue	2945
oriental ditto	2771
common	2520
Bristol	2510
Burford	2049
Portland	2496
rag	2470
rotten	1981
hard paving	2460
mill	2500
clicard, from Brachet	2357
ditto, from Ouchain	2274
Notre Dame	2378
St. Maur	2034
St. Cloud	2201
Sulphur, native	2033
molten	1991
Talc, of Muscovy	2792
black crayon	2089
ditto German	2246
yellow	2655

Talc, black	2900
white	2704
Liquors, oils, &c.	
Acid, sulphuric	1841
ditto, highly concentrated	2125
nitric	1271
ditto, highly concentrated	1580
muriatic	1194
red acetous	1025
white acetous	1014
distilled ditto	1010
fluoric	1500
acetic	1063
phosphoric	1558
formic	994
Alcohol, commercial	837
highly rectified	829
Alcohol, mixed with water,	
15-16ths alcohol	853
14-16ths ditto	867
13-16ths ditto	882
12-16ths ditto	895
11-16ths ditto	908
10-16ths ditto	920
9-16ths ditto	932
8-16ths ditto	943
7-16ths ditto	952
6-16ths ditto	960
5-16ths ditto	967
4-16ths ditto	973
3-16ths ditto	979
2-16ths ditto	985
1-16th ditto	997
Ammoniac, liquid	897
Beer, pale	1024
brown	1038
Cyder	1018
Ether, sulphuric	739
nitric	909
muriatic	738
acetic	860
Milk, woman's	1020
cow's	1032
ass's	1036
ewe's	1041
goat's	1035
mare's	1034
cow's clarified	1019
Oil, essential, of turpentine	870
ditto, of lavender	894
ditto, of cloves	1036
ditto, of cinnamon	1044
of olives	915
of sweet almonds	917
of filberts	916
linseed	940
of walnuts	923
of whale	923
of hempseed	926
of poppies	924
rapeseed	919
Spirit of wine. See Alcohol.	
Turpentine, liquid	991

Urine, human	1011
Water, rain	1000
distilled	1000
sea (average)	1026
of Dead Sea	1240
Wine, Burgundy	992
Bordeaux	994
Madeira	1038
Port	997
Canary	1033
Resins, gums, and animal substances, &c.	
Aloes, socotrine	1380
hepatic	1359
Assafœtida	1328
Bees' wax, yellow	965
white	969
Bone of an ox	1656
Butter	942
Calculus humanus	1700
ditto	1240
ditto	1434
Camphor	989
Copal, opake	1140
Madagascar	1060
Chinese	1063
Crassamentum, human blood	1126
Dragon's blood	1205
Elemi	1018
Fat, beef	923
hog's	937
mutton	924
veal	934
Galbanum	1212
Gamboge	1222
Gum, ammoniac	1207
Arabic	1452
euphorbia	1124
seraphic	1201
tragacanth	1316
bdellium	1372
scammony of Smyrna	1274
ditto of Aleppo	1235
Gunpowder, shaken	932
in a loose heap	836
solid	1745
Honey	1450
Indigo	769
Ivory	1826
Juice of liquorice	1723
of acacia	1515
Labdanum	1186
Lard	948
Mastic	1074
Myrrh	1360
Opium	1336
Scammony. See Gum.	
Serum of human blood	1030
Spermaceti	943
Storax	1110
Tallow	942
Terra Japonica	1398
Tragacanth. See Gum.	
Wax. See Bees'-wax.	

Wax, shoemaker's	897
Woods.	
Alder	800
Apple-tree	793
Ash, the trunk	845
Bay-tree	822
Beech	852
Box, French	912
Dutch	1388
Brazilian red	1031
Campeachy wood	913
Cedar, wild	596
Palestine	613
Indian	1315
American	561
Citron	726
Coco-wood	1040
Cherry-tree	715
Cork	240
Cypress, Spanish	644
Ebony, American	1331
Indian	1209
Elder-tree	695
Elm, trunk of	671
Filbert-tree	600
Fir, male	550
female	498
Hazel	600
Jasmin, Spanish	770
Juniper-tree	556
Lemon-tree	703
Lignum vitæ	1333
Linden-tree	604
Logwood. See Campeachy.	
Mastich-tree	849
Mahogany	1063
Maple	750
Medlar	944
Mulberry, Spanish	897
Oak, heart of, 60 years old	1170
Olive-tree	927
Orange-tree	705
Pear-tree	661
Pomegranate-tree	1354
Poplar	383
white, Spanish	529
Plum-tree	785
Quince-tree	705
Sassafras	482
Vine	1327
Walnut	671
Willow	585
Yew, Dutch	788
Spanish	807

Weight and specific gravities of different gases.

Fahrenheit's therm. 55°	Spec. grav.	Barom. 30 inch. Wt. cub. foot.
Atmospheric air	1.2	525.0 grs.
Hydrogenous gas	0.1	43.75
Oxygenous gas	1.435	627.812
Azotic gas	1.182	517.125
Nitrous gas	1.4544	636.333
Ammoniac. gas	.7311	319.832
Sulphur. acid gas	2.7611	1207.978

In this table the weights and specific gravities of the principal gases are given, as they correspond to a state of the barometer and thermometer which may be chosen for a medium. The specific gravity of any one gas to that of another will not conform to exactly the same ratio under different degrees of heat and other pressures of the atmosphere, because the various expansions by no means follow the same law.

These numbers being the weight of a cubic foot, or 1728 cubic inches, of each of the bodies, in avoirdupois ounces, by proportion the quantity in any other weight, or the weight of any other quantity, may be readily known.

For example. Required the content of an irregular block of millstone which weighs 1 cwt. or 112 lb. or 1792 ounces. Here, as 2500 : 1792 : :1728 : 1228$\frac{4}{5}$ cubic inches the content.

Ex. 2. To find the weight of a block of granite, whose length is 63 feet, and breadth and thickness each 12 feet; being the dimensions of one of the stones of granite in the walls of Balbec. Here $63 \times 12 \times 12 = 9072$ feet is the content of the stone; therefore as 1 : 9072 : : 3500 oz. 31752000 oz. or 885 tons 18 cwt. 3 qrs. the weight of the stone.

XI. A body descends in a fluid specifically lighter, or ascends in a fluid specifically heavier, with a force equal to the difference between its weight and that of an equal bulk of the fluid.

XII. A body sinks in a fluid specifically heavier, so far as that the weight of the body is equal to the weight of a quantity of the fluid of the same bulk as the part immersed. Hence, as the specific gravity of the fluid, is to that of the body, so is the whole magnitude of the body, to the magnitude of the part immersed.

XIII. The specific gravities of equal solids are as their parts immerged in the same fluid.

The several theorems here delivered are both demonstrable from the principles of mechanics, and are also equally comformable to experiment, which answers exactly to the calculation. See Hydrostatics.

Gravity, in music. Gravity is that modification of any sound by which it becomes deep or low in respect of some other sound: the gravity of sounds depends on the thickness and distension of the chords, or the length and diameter of the pipes, and in general on the mass, extent, and tension, of the sonorous bodies. The larger and more lax are the bodies, the slower will be the vibrations, and the graver the sounds.

GRAUSTEIN, in mineralogy, is a rock composed of small grains of felspar and hornblende, which graduate into each other, and form a mass almost homogenous of an ash-grey colour. It contains olivine and augite.

GREAT-circle sailing, the manner of conducting a ship in, or rather pretty near, the arch of a great circle, that passes through the zenith of the two place, viz. whence she came, and to which she is bound.

GREEN-CLOTH, a board, or court of justice, held in the compting-house of the king's household, composed of the lord-steward, and officers under him, who sit daily. To this court are committed the charge and oversight of the king's household in matters of justice and government, with a power to correct all offenders, and to maintain the peace of the verge, or jurisdiciton of the court.

royal; which is every way about two hundred yards from the last gate of the palace where his majesty resides. It takes its name from a green cloth spread over the board where they sit. Without a warrant first obtained from this court, none of the king's servants can be arrested for debt.

Green-finch, in ornithology. See Fringilla.

Green-house, or conservatory, a house in a garden contrived for sheltering and preserving the most tender and curious exotic plants, which, in our climate, will not bear to be exposed to the open air during the winter season. These are generally large and beautiful structures, equally ornamental and useful.

GREENLAND Company. A joint stock of 40,000*l.* was by statute to be raised by subscribers, who were incorporated for 14 years from the 1st of October, 1693, and the company to use the trade of catching whales, &c. into and from Greenland and the Greenland seas. They make bye-laws for the government of the persons employed in their ships, &c. Stat. 4 and 5 W. III. cap. 17. This company was farther encouraged by parliament in 1696; but partly by unskilful management, and partly by real losses, it was under the necessity of entirely breaking up, before the expiration of the term assigned to it, ending in 1707. But any person who will adventure to Greenland for whale-fishing shall have all the privileges granted to the Greenland company by 1 Anne, cap. 16, and thus the trade was again laid open. Any subjects may import whale-fins, oil, &c. of fish caught in the Greenland seas, without paying any customs, &c. Stat. 10 Geo. I. cap. 16. And ships employed in the Greenland fishery are to be of a given burden, provided with boats, so many men, fishing-lines, harping-irons, &c. and be licensed to proceed; and on their return shall be paid 20*s.* per ton bounty for whale-fins, &c. imported. 6 Geo. II. cap. 33. The bounty was afterwards increased, but has been lately diminished; and since this diminution the trade has increased. See Balæna, and Fishery.

GREGORIAN Calendar. See Calendar, and Epact.

Gregorian Epoch, the epocha or time whence the Gregorian calendar or computation took place.

Gregorian Year, the Julian year corrected or modelled, in such a manner as that three secular years, which in the Julian account are bissextile, are here common years, and only every fourth seculiar year is made a bissextile year.

The Julian computation is more than the solar year by eleven minutes, which in 131 years amounts to a whole day. By this calculation the vernal equinox was anticipated 10 days from the time of the general council of Nice, held in the year 325 of the christian æra, to the time of pope Gregory XIII. who therefore caused 10 days to be taken out of the month of October, in 1582, to make the equinox fall on the 21st of March, as it did at the time of that council; and to prevent the like variation for the future, he ordered that three days should be abated in every 400 years, by reducing the leap year at the close of each century for three successive centuries to common years, and retaining the leap-year at the close of each fourth century only. This was at that time esteemed as exactly conformable to the true solar year, but it is found not to be strictly just, because that in 400 years it gets one hour and twenty minutes; and consequently in 7200 years, a whole day.

The greatest part of Europe have long used the Gregorian style; but Great Britain retained the Julian till the year 1752, when by act of parliament this style was adjusted to the Gregorian; since which time Sweden, Denmark. and other European states, who computed time by the Julian account, have followed this example.

GREWIA, a genus of the polyandria order, in the gynandria class of plants, and in the natural method ranking under the 37th order, columniferæ. The calyx is pentaphyllous; there are five petals, each with a nectariferous scale at the base; the berry is quadrilocular. The species are 13. The most remarkable are:

1. The occidentalis, with oval crenated leaves, has long been preserved in many curious gardens both in England and Holland. It is a native of the Cape of Good Hope, and grows to the height of 10 or 12 feet. The stem and branches greatly resemble those of the small-leafed elm, the bark being smooth, and of the same colour with that when young. The leaves are also very like those of the elm, and fall off in autumn. The flowers are produced singly along the young branches from the wings of the leaves, and are of a bright purple colour.

2. The africana, with oval spear-shaped serrated leaves, is a native of Senegal in Africa, whence its seeds were brought by Mr. Adanson. In England it rises with a shrubby stalk five or six feet high, sending out many lateral branches, with a brown hairy bark, and garnished with spearshaped serrated leaves; but the plants have not flowered in Britain.

The first sort, though a native of a warm climate, will bear the open air in this country; only requiring to be sheltered in a green-house during the winter time. It may be propagated by cuttings or layers planted in pots filled with soft loamy earth. The second sort is tender, and must be kept constantly in a warm bark-stove. In summer they require a large share of the free air to be admitted to them, and should have water three or four times a week in warm weather; but in the winter they must be sparingly watered. The negroes of Senegal consider a decoction of the bark of this last species as a never-failing remedy against venereal complaints.

GREWT, among miners, signifies earth of a different colour from the rest, found on the banks of rivers as they are searching for mines.

GREYHOUND. See Canis.

GRIAS, a genus of the monogynia order, in the polyandria class of plants, and in the natural method ranking with those of which the order is doubtful. The corolla is tetrapetalous; the calyx quadrifid; the stigma sessile and cruciform: the fruit is a plum with an eight-furrowed kernel. There is but one species, the cauliflora, or anchovy pear, a native of Jamaica. The leaves are nearly oval. and about three feet long. It has a straight stem, upon the upper part of which come forth the flowers. The fruit is large, and contains a stone with eight furrows. These fruits are eaten by the inhabitants.

GRIELUM, a genus of the pentagynia order, in the decandria class of plants. The calyx is quinquefid; there are five petals; the filaments persisting; and there are five

monospermous seed-cases. There is one species, a herb of the Cape.

GRIFFON, in heraldry, an imaginary animal, feigned by the ancients to be half eagle and half lion; by this form they intended to give an idea of strength and swiftness joined together, with an extraordinary vigilance in guarding the things entrusted to its care.

GRINDING, *trituratio*, the reducing hard substances to fine powders, either by the mortar, or by way of levigation, upon a marble. See MILLWORK.

GRIPE, in the sea language, is a piece of timber stayed against the lower piece of the stern, from the foremast end of the keel, joining with the knee of the head: its use is to defend the lower part of the stern from any injury; but it is often made the larger, to make the ship keep a good wind.

GRISLEA, a genus of the monogynia order, in the octandria class of plants, and in the natural method ranking under the 17th order, calycanthemæ. The calyx is quadrifid; and there are four petals, one from each incisure of it. The filaments are very long, ascending or turning upwards; the capsule is globose, superior, unilocular, and polyspermous. There are two species; one a tree of South America, the other a shrub of the East Indies.

GRIST, in country-affairs, denotes corn ground, or ready for grinding. See FLOUR-MILL.

GRIT, a genus of argillaceous earths. Its texture is more or less porous, equable, and rough to the touch. It does not give fire with steel, nor effervesce with acids. When fresh broken and breathed upon, it exhales an earthy smell. Mr. Kirwan mentions two kinds; one from Hollington, near Uttoxeter, of a yellowish or whitish grey, and about the specific gravity of 2288. Another, from Kneperslev in Staffordshire, is of the specific gravity of 8568, and so infusible as to be used for fire-stones. According to Fabroni the grit-stone is of greater or less hardness, mostly of a grey, and sometimes of a yellowish colour, composed of a siliceous and micaceous sand, but rarely of a sparry kind; with greater or smaller particles closely compacted by an argillaceous cement. It gives some sparks with steel, is indissoluble for the most part in acids, and vitrifiable in a strong fire. It is used for millstones and whetstones, and sometimes for filtering-stones and for building.

GROGRAM, a kind of stuff, made of silk and mohair.

GRONOVIA, a genus of the monogynia order, in the pentandria class of plants, and in the natural method ranking under the 34th order, cucurbitacæ. There are five petals and stamina inserted into a campanulated calyx; the berry is dry, monospermous, and inferior. There is one species, an annual of La Vera Cruz.

GROOM, a name particularly applied to several superior officers belonging to the king's household, as groom of the chamber, groom of the stole.

GROOVE, among miners, is the shaft or pit sunk into the earth, sometimes in the vein, and sometimes not.

GROOVE, among joiners, the channel made by their plough in the edge of a moulding style, or rail, to put their pannels in. in wain-scotting.

GROSS, in law-books, signifies absolute or independent on another: thus, an advowson in gross, is one distinct and separate from the manor.

GROSS also denotes the quantity of twelve dozen, of things sold by tale.

GROSS-BEAK, in ornithology. See LOXIA.

GROSS-WEIGHT, the whole weight of merchandizes, with their dust and dross; as also the bag or chest wherein they are contained. An allowance is usually made out of the gross weight for tare and tret. See TARE.

GROTESQUE, in sculpture and painting, something whimsical, extravagant, and monstrous; consisting either of things that are merely imaginary, and have no existence in nature, or of things so distorted, as to raise surprize and ridicule. Grotesque work is the same with what is sometimes called antique. The name is said to have taken its rise from the figures of this kind much used in adorning the grottos which in ancient times were the tombs of eminent persons or families; such as that of Ovid, whose grotto was discovered near Rome about 100 years ago.

GROTTO, or GROTTA, a large deep cavern or den in a mountain or rock. The word is Italian, grotta; formed, according to Menage, &c. from the Latin crypta. Du Cange observes, that grotta was used in the same sense in the corrupt Latin. The ancient anchorites retired into dens and grottos, to apply themselves the more attentively to meditation. Okey-hole, Elden-hound, Peak's-hole, and Pool's-hole, are famous among the natural caverns or grottos of our country. The entrance to Okey-hole, on the south side of Mendip-hills, is in the fall of those hills, which is beset all about with rocks, and has near it a precipitate descent of near twelve fathoms deep, at the bottom of which there continually issues from the rocks a considerable current of water. The naked rocks above the entrance show themselves about 30 fathoms high, and the whole ascent of the hill above is about a mile, and is very steep. As you pass into this vault, you go at first upon a level; but advancing farther, the way is found to be rocky and uneven, sometimes ascending, and sometimes descending. The roof of this cavern, in the highest part, is about eight fathoms from the ground, but in many particular places it is so low that a man must stoop to get along. The breadth is not less various than the height, for in some places it is five or six fathoms wide, and in others not more than one or two. It extends itself in length about two hundred yards. People talk much of certain stones in it, resembling men and women, and other things; but there is little matter of curiosity in these, being only shapeless lumps of common spar. At the farthest part of the cavern there is a good stream of water large enough to drive a mill, which passes all along one side of the cavern, and at length slides down about six or eight fathoms among the rocks, and then passing through the clefts of them, discharges itself into the valley. The river within the cavern is well stored with eels, and has some trouts in it; and these cannot have come from without, there being so great a fall near the entrance. In dry summers a great number of frogs are seen all along this cavern, even to the farthest part of it; and on the roof of it, at certain places, hang vast numbers of bats, as they do in almost all caverns, the entrance of which is either level, or but slightly ascending or decending; and even in the more perpendicular ones they are sometimes found, provided they are not too narrow, and are sufficiently high. The cattle that feed in the pastures through which this river runs have been

known to die suddenly sometimes after a flood; this is probably owing to the waters having been impregnated, either naturally or accidentally, with lead ore.

Elden-hole is a huge profound perpendicular chasm, three miles from Buxton, ranked among the natural wonders of the Peak. Its depth is unknown, and is pretended to be unfathomable. Cotton tells us he sounded 884 yards, yet the plummet still drew. But he might easily be deceived, unless his plummet was very heavy; the weight of a rope of that length might well make the landing of the plummet scarcely perceivable.

Peak's-hole, and Pool's-hole, are two remarkable horizontal cavities under mountains; the one near Castleton, the other just by Buxton. They seem to have owed their origin to the springs which have their current through them; when the water had forced its way through the horizontal fissures of the strata, and had carried the loose earth away with it, the loose stones must fall down of course: and where the strata had few or no fissures, they remained entire; and so formed these very irregular arches, which are now so much wondered at. The water which passes through Pool's-hole is impregnated with particles of limestone, and has incrusted the whole cavern in such a manner that it appears as one solid rock.

In grottos are frequently found crystals of the rock, stalactites, and other natural conglaciations, and those often of an amazing beauty. M. Homberg conjectures, from several circumstances, that the marble pillars in the grotto of Antiparos vegetate or grow. That author looks on this grotto as a garden, in which the pieces of marble are the plants; and endeavours to show, that they could only be produced by some vegetable principle.

At Foligno in Italy is another grotto, consisting of pillars and orders of architecture of marble, with their ornaments, &c. scarcely inferior to those of art; but they all grow downwards: so that if this too is a garden, the plants are turned upside down.

Grotto *del Cani,* is a little cavern near Pozzuoli, four leagues from Naples, the steams whereof are of a mephitical or noxious quality; whence also it is called bocca venenosa, the poisonous mouth. "Two miles from Naples (says Dr. Mead), just by the Lago de Agnano, is a celebrated Moseta, commonly called la Grotta del Cani, and equally destructive to all within the reach of its vapours. It is a small grotto about eight feet high, twelve long, and six broad; from the ground arises a thin, subtile, warm fume, visible enough to a discerning eye, which does not spring up in little parcels here and there, but in one continued stream, covering the whole surface of the bottom of the cave; having this remarkable difference from common vapours, that it does not, like smoke, disperse itself into the air, but quickly after its rise falls back again, and returns to the earth; the colour of the sides of the grotto being the measure of its ascent: for so far it is of a darkish green, but higher only common earth. And as I myself found no inconvenience by standing in it, so no animal, if its head is above this mark, is the least injured. But when, as the manner is, a dog, or any other creature, is forcibly kept below it; or, by reason of its smallness, cannot hold its head above it, it presently loses all motion, falls down as dead, or in a swoon; the limbs convulsed and trembling, till at last no more signs of life appear than a very weak and almost insensible beating of the heart and arteries; which, if the animal is left a little longer, quickly ceases too, and then the case is irrevocable; but if it is snatched out and laid in the open air, it soon comes to life again, and sooner if thrown into the adjacent lake." The steam or moefite of the grotto del cani is now well known to be carbonic acid gas. See Chemistry.

Grotta del Serpi, is a subterraneous cavern near the village of Sassa, eight miles from the city of Braccano in Italy, described by Kircher thus: "The grotta del serpi is big enough to hold two persons. It is perforated with several fistular apertures, somewhat in the manner of a sieve; out of which, at the beginning of the spring season, issues a numerous brood of young snakes of divers colours, but all free from any particular poisonous quality. In this cave they expose their lepers, paralytics, arthritics, and elephantiac patients, quite naked; where, the warmth of the subterraneous steams resolving them into a sweat, and the serpents clinging variously all around, licking and sucking them, they become so thoroughly freed of all their vicious humours, that upon repeating the operation for some time, they become perfectly restored." This cave Kircher visited himself; and found it warm, and every way agreeable to the description given of it. He saw the holes, and heard a murmuring hissing noise in them. Though he missed seeing the serpents, it not being the season of their creeping out, yet he saw a great number of their exuviæ or sloughs, and an elm growing hard by laden with them. The discovery of the virtues of this cave was by the cure of a leper going from Rome to some baths near this place. Losing his way, and being benighted, he happened upon this cave. Finding it very warm, he pulled off his clothes; and being weary and sleepy, had the good fortune not to feel the serpents about him till they had wrought his cure.

Grotto, *Milky,* Crypta Lactea, a mile distant from the ancient village of Bethlehem, is said to have been thus denominated on occasion of the Blessed Virgin, who let fall some drops of milk in giving suck to Jesus in this grotto. And hence it has been commonly supposed, that the earth of this cavern has the virtue of restoring milk to women that are grown dry, and even of curing fevers. Accordingly, they are always digging in it, and the earth is sold at a good rate to such as have folly enough to give credit to the fable. An altar has been built on the place, and a church just by it.

Grotto is also used for a little artificial edifice made in a garden, in imitation of a natural grotto. The outsides of these grottos are usually adorned with rustic architecture, and their inside with shell-work, fossils, &c. finished likewise with jets-d'eau or fountains, &c. A cement for artificial grottos may be made thus: Take two parts of white rosin, melt it clear, and add to it four parts of bees'-wax; when melted together, add two or three parts of the powder of the stone you design to cement, or so much as will give the cement the colour of the stone. With this cement, the stone, shells, &c. after being well dried before the fire, may be cemented. Artificial red coral branches, for the embellishment of grottos, may be made in the following manner: Take clear rosin, dissolve it in a brass-pan, to every ounce of which add two drams of the finest vermilion; when you have stirred

them well together, and have chosen your twigs and branches, peeled and dried, take a pencil and paint the branches all over whilst the composition is warm; afterwards shape them in imitation of natural coral. This done, hold the branches over a gentle coal-fire, till all is smooth and even as if polished. In the same manner white coral may be prepared with white lead, and black coral with lamp-black. A grotto may be built with little expense, of glass, cinders, pebbles, pieces of large flint, shells, moss, stones, counterfeit coral, pieces of chalk, &c. all bound or cemented together with the above-described cement.

GROUND, in painting, the surface upon which the figures and other objects are represented. See PAINTING.

GROUND-TACKLE, a ship's anchors, cables, and in general whatever is found necessary to make her ride safe at anchor.

GROUND-IVY, in botany. See GLECHOMA.

GROUND-*Pine*. See TEUCRIUM.

GROUNDAGE, a custom or tribute paid for the ground on which a ship stands in port.

GROUNDSEL, in botany, &c. See SENECIO.

GROUP, in painting and sculpture, is an assemblage of two or more figures of men, beasts, fruits, &c. which have some apparent relation to each other, &c. See PAINTING.

GROUSE, or GROWSE. See TETRAO.

GROWAN, among the miners of Cornwall, a coarse gritty stone, of a greyish colour, which they are often obliged to dig through before they can reach the ore.

GRUNSTEIN, primitive, is a mixture of hornblende and felspar; and is divided into different varieties, according as its texture is granular or compact. See ROCKS PRIMITIVE.

GRY, a measure containing one-tenth of a line. A line is one-tenth of a digit, and a digit one-tenth of a foot, and a philosophical foot one-third of a pendulum whose diadromes, or vibrations, in the latitude of 45 degrees, are each equal to one second of time, or one-sixtieth of a minute.

GRYGALLUS, in ornithology, a name given to the urogallus, or tetrao. See TETRAO.

GRYLLUS, the *locust*, *grasshopper*, and *cricket*, in entomology, a genus of insects belonging to the order hemiptera. The generic character is, head inflected, armed with jaws, and furnished with feelers. Antennæ, in most species, either filiform or setaceous. Wings four, deflex, convoluted: lower wings pleated. Hind legs formed for leaping: claws double on all the feet. There are 61 species, of which the following are most worthy of notice:

1. Among the most numerous species is the gryllus migratorius of Linnæus, or common migratory locust, which of all the insects capable of injuring mankind seems to possess the most dreadful powers of destruction. Legions of these animals are from time to time observed in various parts of the world, where the havock they commit is almost incredible: whole provinces are in a manner desolated by them in the space of a few days, and the air is darkened by their numbers: nay even when dead they are still terrible; since the putrefaction arising from their inconceivable number is such that it has been regarded as one of the probable causes of pestilence in the Eastern regions. This formidable locust is generally of a brownish colour, varied with pale red, or flesh-colour, and the legs are frequently blueish. In the year 1748, it appeared in irregular flights in several parts of Europe, as in Germany, France, and England; and in the capital itself and its neighbourhood great numbers were seen: they perished, however, in a short time, and were happily not productive of any material mischief, having been probably driven by some irregular wind out of their intended course, and weakened by the coolness of the climate.

From a paper published in the 18th volume of the Philosophical Transactions we find, that in the year 1693, swarms of this species of locust settled in some parts of Wales. Two vast flights were observed in the air not far from the town of Dolgalken, in Merionethshire: the others fell in Pembrokeshire. From a letter published in the 38th volume of the same work, it appears, that some parts of Germany, particularly in the march of Brandenburgh, &c. suffered considerable injury from the depredations of these animals. They made their appearance in the spring of the year 1732, from flights which had deposited their eggs in the ground the preceding year. They attacked and devoured the young spike of the wheat, &c. and this chiefly by night, and thus laid waste many acres at a time beyond all hope of recovery. In the 46th volume of the same Transactions we find a description of the ravages of these animals in Wallachia, Moldavia, Transylvania, Hungary, and Poland, in the years 1747 and 1748.

"The first swarms entered into Transylvania in August 1747: these were succeeded by others, which were so surprizingly numerous, that when they reached the Red Tower, they were full four hours in their passage over that place; and they flew so close that they made a sort of noise in the air by the beating of their wings against one another. The width of the swarm was some hundreds of fathoms, and its height or density may be easily imagined to be more considerable, inasmuch as they hid the sun and darkened the sky, even to that degree, when they flew low, that people could not know one another at the distance of twenty paces; but as they were to fly over a river that runs in the valleys of the Red Tower, and could find neither resting-place nor food; being at length tired of their flight, one part of them lighted on the unripe corn on this side of the Red Tower, such as millet, Turkish wheat, &c.; another pitched on a low wood, where, having miserably wasted the produce of the land, they continued their journey, as if a signal had actually been given for a march. The guards of the Red Tower attempted to stop their irruption into Transylvania by firing at them; and indeed, where the balls and shot swept through the swarm, they gave way and divided; but having filled up their ranks in a moment, they proceeded on their journey. In the month of September, some troops of them were thrown to the ground by great rains and other inclemency of the weather, and thoroughly soaked with wet: they crept along in quest of holes in the earth, dung, and straw; where being sheltered from the rains, they laid a vast number of eggs, which stuck together by a viscid juice, and were longer and smaller than what is commonly called an ant's egg (the chrysalis of the formica) very like grains of oats.

In the spring of 1748, certain little blackish worms were seen lying in the fields and among the bushes, sticking together, and collecting in clusters, not unlike the hillocks of moles or ants. As nobody knew what they were, so there was little or no notice taken of them, and in May they were covered by the shooting of the corn sown in winter; but the subsequent June discovered what those worms were; for then, as the corn sown in spring was pretty high, these creatures began to spread over the fields, and become destructive to the vegetables by their numbers. At that time they differed little or nothing from our common grasshoppers; having their head, sides, and back, of a dark colour, with a yellow belly, and the rest of a reddish hue. About the middle of June, according as they were hatched sooner or later, they were generally a finger's length, or somewhat longer, but their shape and colour still continued. Towards the end of June they cast off their outward covering, and then it plainly appeared that they had wings; and as soon as any of them found themselves able to use their wings, they soared up, and by flying round the others, enticed them to join them. Wherever those troops happened to ch, they spared no sort of vegetable: they ate up the young corn, and the very grass; but nothing was more dismal than to behold the lands in which they were hatched; for they so greedily devoured every thing green, before they could fly, that they left the ground quite bare.

"There is nothing to be feared in those places to which this plague did not reach before the autumn; for the locusts have not strength to fly to any considerable distance but in the months of July, August, and the beginning of September; and even then, in changing their places of residence, they seem to tend to warmer climates.

"Different methods are to be employed, according to the age and state of these insects; for some will be effectual as soon as they are hatched, others when they begin to crawl, and others when they begin to fly. It would be of great service to seek out the places where the females lodged; for nothing was more easy than carefully to visit those places in March and April, and to destroy their eggs or little worms with sticks or briars; but in the summer, when they have marched out of their spring-quarters, and have invaded the corn-fields, &c. it is almost impossible to extirpate them without thoroughly thrashing the whole piece of land that harbours them with sticks or flails, and thus crushing the locust with the produce of the land. Finally, when the corn is ripe or nearly so, there is no other method of getting rid of them, or even of diminishing their numbers, than to surround the ground with a multitude of people, who might fright them away with bells, brass vessels, and all other sorts of noise. But even this method will not succeed till the sun is pretty high.

"It will likewise be of use, where a large troop of them has pitched, to dig a long trench, of an ell width and depth, and place several persons along its edges, provided with brooms, while another numerous set of people form a semicircle that takes in both ends of the trench, and encompasses the locusts; and by making the noise above-mentioned, drive them into the trench, out of which if they attempt to escape, those on the edges are to sweep them back, and then crush them with their brooms and stakes, and bury them by throwing in the earth again. But when they have begun to fly, there should be horsemen upon the watch in the fields, who, upon any appearance of the swarm taking wing, should immediately alarm the neighbourhood by a certain signal, that they might come and fright them from their lands by all sorts of noise; and if, tired with flying, they happen to pitch on a waste piece of land, it will be very easy to kill them with sticks and brooms in the evening or early in the morning, while they are wet with the dew; or any time of the day in rainy weather, for then they are not able to fly."

We have before observed, that the locusts which fell in several parts of England, and in particular in the neighbourhood of the metropolis, in the year 1748, were evidently some straggling detachments from the vast flights which in that year visited many of the inland parts of the European continent.

The ravages of locusts in various parts of the world, at different periods, are recorded by numerous authors. In the year 593 of the Christian era, after a great drought, these animals appeared in such vast legions as to cause a famine in many countries. In 677 Syria and Mesopotamia were overrun by them. In 852, immense swarms took their flight from the Eastern regions into the West, flying with such a sound that they might have been mistaken for birds: they destroyed all vegetables, not sparing even the bark of trees and the thatch of houses; and devoured the corn so rapidly, as to destroy, on computation, a hundred and forty acres in a day: their daily marches or distances of flight were computed at twenty miles; and these were regulated by leaders or kings, who flew first, and settled on the spot which was to be visited at the same hour the next day by the whole legion: these marches were always undertaken at sunrise. These locusts were at length driven by the force of winds into the Belgic ocean, and being thrown back by the tide and left on the shores, caused a dreadful pestilence by their smell. In 1271, all the corn-fields of Milan were destroyed; and in the year 1339 all those of Lombardy. In 1541, incredible hosts afflicted Poland, Wallachia, and all the adjoining territories, darkening the sun with their numbers, and ravaging all the fruits of the earth.

2. One of the largest species of locust yet known is the gryllus cristatus of Linnæus, which is five or six times the size of the gryllus migratorius, and, together with some others of the larger kind, is made use of in some parts of the world as an article of food: they are eaten both fresh and salted, in which last state they are publicly sold in the markets of some parts of the Levant. The quantity of edible substance which they afford is but small, especially in the male insects; but the females, on account of the ovaries, afford a more nutritious sustenance.

The gryllus cristatus is a highly beautiful animal; being of a bright red, with the body annulated with black; and the legs varied with yellow: the upper wings tesselated with alternate variegations of dark and pale green; the lower with transverse undulated streaks: the length of the animal from head to tail is about four inches, and the expanse of wings from tip to tip, when fully extended, hardly less than seven inches and a half.

3. Greatly allied to the preceding is the gryllus dux; it is of the same size and general appearance, but has the body

green; the upper wings brown, with the front edge green; and the lower wings red, with numerous black spots disposed in such a manner as to form transverse streaks. It is a native of South America and the West Indian islands.

4. The gryllus viridissimus of Linnæus is one of the largest European species, and is often seen during the decline of summer in our own country. It is wholly of a pale grass-green, with a slight blueish cast on the head and under part of the thorax, which is marked above by a longitudinal reddish-brown line: the length of the insect, from the mouth to the tips of the wings, is about two inches and a half: the female is distinguished by a long sword-shaped process at the end of the body, being the instrument with which she pierces the ground in order to deposit her eggs: it consist of a pair of valves, through the whole length of which the eggs are protruded: they are of an oblong form, and a pale brown colour.

5. The gryllus verrucivorus is also found in some parts of England, and is of an equal size with the viridissimus, but of a reddish-brown colour, with darker variegations: this animal, according to Linnæus, is frequently applied by the people of Sweden to warts on the hands, which it is suffered to bite off, and is said thus to prevent their return.

6. But of all the British insects of this genus the gryllus gryllotalpa or mole-cricket is by far the most curious; and in its colour and manners differs greatly from the rest. It is of an uncouth, and even formidable aspect, measuring more than two inches in length; and is of a broad and slightly flattened shape, of a dusky brown colour, with a ferruginous cast on the under parts, and is readily distinguished by the extraordinary structure of its fore-legs, which are excessively strong, and furnished with very broad feet, divided into several sharp, claw-shaped, segments, with which it is enabled to burrow under ground in the manner of a mole: the lower wings, which when expanded are very large, are, in their usual state, so complicated under the very short and small upper wings or sheaths, that their ends alone appear, reaching, in a sharpened form, along the middle of the back; the abdomen is terminated by a pair of sharp-pointed, lengthened, hairy processes, nearly equalling the length of the antennæ in front, and contributing to give this animal an appearance in some degree similar to that of a blatta.

The mole-cricket emerges from its subterraneous retreats only by night, when it creeps about the surface, and occasionally employs its wings in flight. It prepares for its eggs an oval nest, measuring about two inches in its longest diameter: this nest is situated a hand's breadth below the surface of the ground: it is accurately smoothed within, and is furnished with an obliquely curved passage leading to the surface. The eggs are about two hundred and fifty or three hundred in number, nearly round, of a deep brownish yellow colour, and of the size of common shot: on the approach of winter, or any great change of weather, these insects are said to remove the nest, by sinking it deeper, so as to secure it from the power of frost; and when the spring commences, again raising it in proportion to the warmth of the season, till at length it is brought so near the surface as to receive the full influence of the air and sunshine; but should unfavourable weather again take place, they again sink the precious deposit, and thus preserve it from danger. The eggs are usually deposited in the months of June and July, and the young are hatched in August. At their first exclusion they are about the size of ants, for which, on a cursory view, they might be mistaken; but on a close inspection are easily known by their broad feet, &c. In about the space of a month they are grown to the length of more than a quarter of an inch; in two months upwards of three quarters; and in three months to the length of more than an inch. Of this length they are usually seen during the close of autumn, after which they retire deep beneath the surface; not appearing again till the ensuing spring. During ther growth they cast their skin three or four times.

The mole-cricket lives entirely on vegetables, devouring the young roots of grasses, corn, and various esculent plants, and commits great devastation in gardens. It is found in most parts of Europe, and in the northern parts of Asia and America.

7. The tettigonia or grasshopper, well known in our meadows, belongs to this genus.

8. The acheta or cricket, of which there are two varieties, the hearth and the field cricket.

9. The griseus is found in Italy. (See Plate LXVII. Nat. Hist. fig. 215.)

10. The stridulus inhabits most parts of Europe. (See Plate LXVII. Nat. Hist. fig. 216.)

GRYPHITES, in natural history, in English crow's-stone, an oblong fossil shell, very narrow at the head, and becoming gradually wider to the extremity, where it ends in a circular limb; the head or beak of this is very hooked or bent inward. They are frequently found in their gravel or clay-pits, in many counties. There are three or four distinct species of them; some are extremely rounded and convex on the back, others less so: and the plates of which they are composed, are in some smaller and thinner, in others thicker and larger, in specimens of the same bigness.

GUAIACUM, *lignum vitæ*, or *pockwood;* a genus of the monogynia order, in the decandria class of plants, and in the natural method ranking under the 14th order, gruinales. The calyx is quinquefid and unequal: the petals five, and inserted into the calyx; the capsule is angulated, and trilocular or quinquelocular. The species are 4: 1. The officinale, or common lignum vitæ used in medicine, is a native of the West India islands and the warmer parts of America. (See Pl. LXVII. Nat. Hist. fig. 217.) There it becomes a large tree, having a hard, br [illegible] tle, brownish bark, not very thick. The wood is f[illegible]rm, solid, ponderous, very resinous, of a blackish yello[illegible]w colour in the middle, and of a hot aromatic taste [illegible]. The smaller branches have an ash-coloured bark, a[illegible] divided by pairs of a bright green colour. T[illegible]d leaves are produced in clusters at the end of the br[illegible]ne flowers are composed of oval concave petals of a fine [illegible]anches, and 2. The sanctum, with many pairs of obt[illegible] blue colour. many small lobes placed along the mid-ri[illegible]ase lobes, and darker green colour than those of the [illegible]b by pairs of a The flowers are produced in loose bu[illegible] foregoing sort. end of the branches, and are of a fin[illegible]ches towards the petals fringed on the edges. This sp[illegible]e blue colour, with of the West India islands, where it [illegible]ecies is also a native num vitæ. 3. The afrum, with ma[illegible] is called bastard lig- [illegible]y blunt-pointed leaves,

is a native of the Cape of Good Hope. The plants retain their leaves all the year, but have never yet flowered in this country. 4. The dubium, a native of the South Seas.

The first species can only be propagated by seeds, which must be procured from the countries where it naturally grows. They must be sown fresh in pots, and plunged into a good hotbed, where they will come up in six or eight weeks. While young, they may be kept in a hotbed of tan-bark under a frame during the summer; but in autumn they must be removed into the bark stove, where they should constantly remain. The second sort may be propagated the same way; but the third is to be propagated by layers, and will live all the winter in a good greenhouse.

The wood of the first species is of very considerable use both in medicine and in the mechanical arts. It is so compact and heavy as to sink in water. The outer part is often of a pale-yellowish colour; but the heart is blacker, or rather of a deep brown. Sometimes it is marbled with different colours. It is so hard as to break the tools which are employed in felling it, and is therefore seldom used as fire-wood, but is of great use to the sugar-planters for making wheels and cogs to sugar-mills. It is also frequently wrought into bowls, mortars, and other utensils. It is brought over hither in large pieces of four or five hundred weight each; and from its hardness and beauty is in great demand for various articles of turnery ware.

The wood, gum, bark, fruit, and even the flowers of this tree, have been found to possess medicinal virtues; but it is only the 3 first, and more particularly the wood and resin, which are now in general use in Europe. The wood has little or no smell, except when heated, or while rasping, and then a slight aromatic one is perceived. When chewed, it impresses a mild acrimony, biting the palate and fauces. Its pungency resides in its resinous matter, which it gives out in some degree to water by boiling, but spirit extracts it wholly.

The resin is obtained by wounding the bark in different parts of the body of the tree, or by what has been called jagging. It exudes copiously from these wounds, though gradually; and when a quantity is found accumulated upon the several wounded trees, hardened by exposure to the sun, it is gathered and packed in small kegs for exportation. The resin is of a friable texture, of a deep greenish colour, and sometimes of a reddish hue; it has a pungent acrid taste, but little or no smell unless heated. The tree also yields a spontaneous exudation from the bark, which is called the native gum, and is brought to us in small irregular pieces, of a bright semi-pellucid appearance, and differs from the former in being much purer.

Guaiacum was first introduced into Europe as a remedy for the venereal disease, and appears to have been used in Spain so early as 1508. The great success attending its administration before the proper use of mercury was known, brought it into such repute, that it is said to have been sold for seven old crowns a pound. It did not, however, continue to maintain its reputation; but was found generally to fail where the disease was inveterate, and was at length superseded by mercury, to which it now only serves occasionally as an adjuvant. The general virtues of guaiacum, are those of a warm stimulating medicine, strengthening the stomach and other viscera, and remarkably promoting the urinary and cuticular discharges: hence in cutaneous eruptions, it is deemed eminently useful; as well as in the rheumatism when given in a sufficient dose. The resin is the most active, and the efficacy of the wood, &c. depends upon the quantity of this contained in them. The resin is given from a few grains to a scruple or half a dram, which last dose proves for the most part considerably purgative. Dissolved in spirit of wine, and afterwards combined with water, by means of mucilage or the yolk of egg, or in form of the simple or volatile tincture, it is much employed in gout and chronic rheumatism. These last have been given to the extent of half an ounce twice a day, and are sometimes usefully combined with tincture of opium. See Resins.

GUARDIAN, one appointed by the wisdom and policy of the law, to take care of a person and his affairs, who by reason of his imbecility and want of understanding is incapable of acting for his own interest; and it seems by our law, that his office originally was to instruct the ward in the arts of war, as well as those of husbandry and tillage, that when he came of age he might be the better able to perform those services to his lord, whereby he held his own land. 2 Bac. Abr. 672.

There are several kinds of guardians, as, guardian by nature, guardian by the common law, guardian by statute, guardian by custom, guardian in chivalry, guardian in soccage, and guardian by appointment of the lord chancellor.

Guardian by nature, is the father or mother; and here it should be observed, that by the common law every father has a right of guardianship of the body of his son and heir, until he attains the age of twenty-one years. Co. Lit. 84.

This guardianship extends no further than the custody of the infant's person. 1 Inst. 84.

It yields as to the custody of the person, to guardianship in soccage, where the title to both guardianships concur in the same individuals. 1 Inst. 88 b.

But guardianship in soccage ending at 14, it seems that after that age, the father or other ancestor, having a like title to both guardianships, becomes guardians by nature till the infant's age of 21. Carth. 384.

Lastly, the father may disappoint the mother, and other ancestors, of the guardianship by nature, by appointing a testamentary guardian under the statutes 4 and 5 P. et M. and 12 Car. II.

Guardian by nature, has only the care of the person and education of the infant, and has nothing to do with his lands merely in virtue of his office; for such guardian may be though the infant have no lands at all, which a guardian in soccage cannot. Co. Lit. 88.

Guardian by the common law. If a tenant in soccage dies, his heir being under 14, whether he is his issue or cousin, male or female, the next of blood to the heir, to whom the inheritance cannot descend, shall be guardian of his body and land till his age of fourteen; and although the nature of soccage tenure is in some measure changed from what it originally was, yet it is still called soccage tenure, and the guardian in soccage is still only where lands of that kind, as most of the lands in England now are, descend to the heir within age; and though the heir after 14 may choose his own guardian, who shall con-

tinue till he is 21, yet as well the guardian before 14, as he whom the infant shall think fit to choose after 14, are both of the same nature, and have the same office and employment assigned to them by the law, without any intervention or direction of the infant himself: for they were therefore appointed, because the infant in regard of his minority, was supposed incapable of managing himself and his estate, and consequently derive their authority not from the infant, but from the law: and that is the reason they transact all affairs in their own name, and not in the name of the infant, as they would be obliged to do if their authority was derived from him. Co. Lit. 87.

Hence the law has invested them, not with a bare authority only, but also with an interest till the guardianship ceases; and to prevent their abuse of this authority and interest, the law has made them accountable to the infant, either when he comes to the age of 14 years, or at any time after, as he thinks fit; and therefore are not to have any thing to their own use, as the guardian in chivalry had. Co. Lit. 90. a.

Guardian by statute. By the common law, no person could appoint a guardian, because the law had appointed one, whether the father was tenant by knight service, or in soccage. 3 Co. 37.

The first statute that gave the father a power of appointing, was the 4 and 5 P and M. c. 8. which provides under severe penalties, such as fine and imprisonment for years, that no one shall take away any maid or woman child unmarried, being within the age of sixteen years, out of or from the possession, custody, or governance, and against the will, of the father of such maid or woman child, or of such person or persons to whom the father of such maid or woman child, by his last will and testament, or by any other act in his life-time, has or shall appoint, assign, bequeath, give, or grant the order, keeping, education and government, of such maid or woman child. 1 Sid. 362.

In the construction of this statute, the following opinion has been holden. That a testamentary guardian, or one formed according to this statute, comes in loco parentis, and is the same in office and interest with a guardian in soccage, and differs only as to the modus habendi, or in a few particular circumstances; as first that it may be held for a longer time, viz. till the heir attains the age of 21, whereas before it was but 14; secondly, it may be by other persons held, for before it was the next of kindred not inheritable could have it; and now who the father names shall have it. Vaugh. 178.

Guardian by custom. By the custom of the city of London, the custody and guardianship of orphans under age, unmarried, belongs to the city. 2 Bac. Abr. 675.

By the custom of Kent, where any tenant died, his heir being within age, the lord of the manor might and did commit the guardianship to the next relation within the court of justice in whose jurisdiction the land was; but the lord was bound on all occasions to call him to account, and if he did not see that the accounts were fair, the lord himself was bound to answer it. This province the lord chancellor has taken from inferior courts, only in Kent, where these customs are continued.

Guardian in chivalry. By the common law, if tenant by knight-service had died, his heir male being under the age of twenty-one years, the lord shall have the land holden of him, till such heir had arrived at that age, because till then he was not intended to be able to do such service; and such lord had likewise the custody of the body of the infant, to bring him up, and inure him to martial discipline, and was therefore called guardian in chivalry. Co. Lit. 74. This priviledge of wardship is now abolished.

Guardian in soccage. Guardians in soccage are also called guardians by the common law. Wardship is incident to tenure in soccage, but of a nature very different from that which was formerly incident to knight-service; for if the inheritance descends to an infant under 14, the wardship of him does not, nor ever did, belong to the lord of the fee; because in this tenure, no military or other personal service being required, there was no occasion for the lord to take the profits in order to provide a proper substitute for his infant tenant. Co. Lit. 84.

Guardian by appointment of the lord chancellor. It is not easy to state how this jurisdiction was acquired; it is certainly of no very ancient date, though indisputable: for it is clearly agreed, that the king, as pater patriæ, is universal guardian of all infants, ideots, and lunatics, who cannot take of themselves; and as this care cannot be exercised otherwise than by appointing them proper curators or committees, it seems also agreed, that the king may, as he has done, delegate the authority to his chancellor; and that therefore at this day, the court of chancery is the only proper court, that has jurisdiction in appointing and removing guardians, and in preventing them and others from abusing their persons or estates. 2 Inst. 14. And as the court of chancery is now vested with this authority, hence in every day's practice, we find that court determining, as to the right of guardianship, who is the next of kin, and who the most proper guardian; as also orders are made by that court on petition or motion, for the provision of infants during any dispute therein; as likewise guardians removed or compelled to give security; they and others punished for abuses committed on infants, &c.

Guardian of the spiritualities, the person to whom the spiritual jurisdiction of any diocese is committed, during the time the see is vacant. A guardian of the spiritualities may likewise be either such in law, as the archbishop is of any diocese within his province; or by delegation, as he whom the archbishop or vicar-general for the time appoints. Any such guardian has power to hold courts, grant licences, dispensations, probates of wills, &c.

GUAPERVA. See Chætodon.

GUAREA, a genus of the class and order octandria monogynia. The cal. is four-cleft; pet. four; nect. cylindric, bearing the anthers at its mouth; caps. four-valved, four-celled; seeds solitary. There is one species; a tree of the West Indies.

GUDGEON, in ichthyology. See Cyprinus.

Gudgeons, in a ship, are the eyes drove into the stern-post, into which the pintles of the rudder go, to hang it.

In vol. XI. of the Transactions of the Society for the Encouragement of Arts, &c. we have the following account of a gudgeon on an improved construction for the upright shafts of mills. "This gudgeon is formed of

hard steel, and works on a hard steel bed; is circular, three inches in diameter, and three-fourths of an inch thick: from its upper side a rib projects, which being fixed in the bottom of an upright shaft, the gudgeon works horizontally on a square bed: and that now in the possession of the society has worked in a mill whose wheel and shaft weighed nearly six tons; and though it had continued to work seven years, had lost very little of its surface. It ran in a square box of cast iron, having oil therein: and a notch along the whole of the face of the gudgeon admits the oil to insinuate itself between the gudgeon and the bed."

GUETTARDA, a genus of the heptandria order, in the monœcia class of plants, and in the natural method ranking under the 38th order, tricoccæ. The male calyx is cylindrical; the corolla cleft into seven parts, and funnel-shaped. The female calyx cylindrical; the corolla cleft into seven parts; one pistil, and the fruit a dry plum. There are four species, trees of the East and West Indies.

GUILANDINA, the nickar tree; a genus of the monogynia order, in the decandria class of plants, and in the natural method ranking under the 33d order, lomentaceæ. The calyx is monophyllous and salver-shaped; the petals inserted into the neck of the calyx, nearly equal. The seed-vessel a legumen. The species are six; the most remarkable are, 1. The bonduc, or yellow nickar. 2. The bonducella, or grey nickar. These are climbing plants, natives of the West Indies, where they rise to the height of 12 or 14 feet: the flowers come out at the wings of the stalks, and are composed of five concave yellow petals. They are succeeded by pods about three inches long and two broad, closely armed with slender spines, opening with two valves, each inclosing two hard seeds about the size of children's marbles, of a yellowish colour. 3. The moringa, or morunga nickar, is a native of the island of Ceylon, and some places on the Malabar coast. It rises to the height of 25 or 30 feet, having flowers produced in loose bunches from the sides of the branches, and composed of an unequal number of petals.

These plants, being natives of warm climates, require to be kept through the winter in a stove. They are propagated by seeds; but those of the first sort are so hard, that unless they are soaked two or three days in water before they are put into the ground, or placed under the pots in the tan-bed to soften their covers, they will remain for years without vegetating. The roots of the third sort are scraped when young, and used by the inhabitants of Ceylon and Malabar, as those of horse-radish are in Europe. The wood dyes a beautiful blue colour. It is the lignum nephriticum of the dispensatories, and is brought over in large, compact, ponderous pieces, without knots, of a whitish or pale-yellow colour on the outside, and dark-coloured or reddish within: the bark is usually rejected. This wood imparts to water or rectified spirit a deep tincture; appearing, when placed between the eye and the light of a golden-colour, in other situations blue: pieces of another wood are sometimes mixed with it, which give only a yellow colour to water. The nephritic wood has scarcely any smell, and very little taste. It stands recommended in difficulty of urine, and all nephritic complaints, and is said to have this peculiar advantage; that it does not, like the warmer diuretics, heat or irritate the urinary passages. Practitioners, however, have not found these praises warranted by experience.

GUILD (from the Saxon guildan "to pay"), signifies a fraternity or company, because every one was a gildare, that is, to pay something towards the charge and support of the company. As to the original of these guilds or companies, it was a law among the Saxons, that every freeman of fourteen years of age should find sureties to keep the peace, or be committed: upon which certain neighbours, consisting of ten families, entered into an association, and became bound for each other, either to produce him who committed an offence, or to make satisfaction to the injured party: that they might the better do this, they raised a sum of money among themselves, which they put into a common stock; and when one of their pledges had committed an offence, and was fled, then the other nine made satisfaction out of this stock, by payment of money according to the offence. Because this association consisted of ten families, it was called a decennary: and hence proceeded later kinds of fraternities. But as to the precise time when these guilds had their origin in England, there is nothing of certainty to be found; since they were in use long before any formal licence was granted to them for such meetings. It seems to have been about the close of the eleventh century, says Anderson in his History of Commerce, vol. i. p. 70, that merchant-guilds, or fraternities, which were afterwards styled corporations, came first into general use in many parts of Europe. Mr. Madox, in his Firma Burgi, chap. i. § 9. thinks they were hardly known to our Saxon progenitors, and that they might be probably brought into England by the Normans, although they do not seem to have been very numerous in those days. The French and Normans might probably borrow them from the free cities of Italy, where trade and manufactures were much earlier propagated, and where possibly such communities were first in use. These guilds are now companies joined together, with laws and orders made by themselves, by the licence of the prince.

GUILD, in the royal boroughs of Scotland, is still used for a company of merchants, who are freemen of the borough. (See BOROUGH.) Every royal borough has a dean of guild, who is the next magistrate below the baliff. He judges of controversies among men concerning trade; disputes between inhabitants touching buildings, lights, water-courses, and other nuisances; calls courts, at which his brethren of the guild are bound to attend; manages the common stock of the guild; and amerces and collects fines.

GUINEA-PIG. See CAVIA.

GUINEA-WORM. See DRACUNCULUS.

GUITAR, or GUITARRA, a musical instrument of the string-kind, with five double rows of strings, of which those that are bass, are in the middle, unless it be for the burden, an octave lower than the fourth.

GULA, or GOLA. See ARCHITECTURE.

GULES, in heraldry, signifies the colour red, which is expressed in engraving by perpendicular lines falling from the top of the escutcheon to the bottom.

GUM. A thick, transparent, tasteless fluid, which sometimes exudes from certain species of trees. It is

very adhesive, and gradually hardens without losing its transparency; but easily softens again when moistened with water. The gum most commonly used is that which exudes from different species of mimosa, particularly the nilotica. It is known by the name of gum arabic. Gum likewise exudes abundantly from the prunus avium, or common wild cherry-tree of this country.

Gum is usually obtained in small pieces like tears, moderately hard, and somewhat brittle while cold, so that it can be reduced by pounding to a fine powder. When pure it is colourless, but it has usually a yellowish tinge, and it is not destitute of lustre. It has no smell. Its taste is insipid. Its specific gravity varies from 1.31 to 1.48.

1. Gum undergoes no change from being exposed to the atmosphere; but the light of the sun makes it assume a white colour. Water dissolves it in large quantities. The solution which is known by the name of mucilage, is thick and adhesive: it is often used as a paste, and to give stiffness and lustre to linen. When spread out thin it soon dries, and has the appearance of a varnish; but it readily attracts moisture, and becomes glutinous. Water washes it away entirely. When mucilage is evaporated the gum is obtained unaltered. This mucilaginous solution may be kept for years without undergoing putrefaction. Scarcely any vegetable substance is less liable to decomposition. At last, however, the odour of acetic acid becomes perceptible in it.

When gum is exposed to heat it softens and swells, but does not melt; it emits air-bubbles, blackens, and at last, when nearly reduced to charcoal, emits a low blue flame. This flame appears sooner if a flaming substance is held just above the gum. After the gum is consumed, there remains a small quantity of white ashes, composed chiefly of the carbonats of lime and potass.

2. It does not appear that gum is acted upon by oxygen gas. A solution of gum and water, when exposed to the air, soon becomes mouldy on the surface, but undergoes no farther change for a long time. The action of the simple combustibles on gum has scarcely been examined. Azotic gas seems to have no action on it whatever.

Gum does not act upon metals; but it has the property of combining with several of the metallic oxides, and forming compounds: at least, some of the salts occasion precipitates when dropt into solutions of gum. The most curious effect is that produced by the oxymuriat of iron. When this salt, concentrated, is dropt into a very strong mucilage, the whole becomes a brown semitransparent jelly, which is not readily dissolved by water. When dried, the jelly becomes lighter-coloured, and assumes nearly the appearance of gum. Its taste is that of gum mixed with iron.

Liquid potass first converts gum into a substance not unlike curd, and then dissolves it. The solution is of a light amber-colour, and transparent. When long kept, the gum again falls into the state of curd. Alcohol throws down the gum in white flakes still soluble in water; but it retains the potass obstinately, and is much more friable than before. Lime-water and ammonia likewise dissolve gum, and it may be afterwards separated little altered.

Charcoal powder, when mixed with a solution of gum in water, gives it a black colour, which cannot be removed by filtration, unless a very great proportion of the powder is added. In that case the water passes clear; but the whole of the gum is retained by the charcoal. Mr. Lowitz found that not less than 30 lbs. of charcoal powder must be mixed with water containing an ounce of gum dissolved in it, before the water is entirely deprived of the gum.

The vegetable acids dissolve gum without alteration; the strong acids decompose it. Sulphuric acid converts it into water, acetous acid, and charcoal. The same effect is said by Fourcroy to be produced by muriatic acid. But this is not accurate unless some heat is applied. When gum is dissolved in strong muriatic acid, a brown solution is obtained; which becomes perfectly transparent when diluted with water, while at the same time some charry matter falls. If the solution is now saturated with ammonia, evaporated to dryness, and the residue digested in alcohol, the alcohol assumes a deep-brown colour, and dissolves the whole except a very little sal ammoniac. The gum now bears some resemblance to sugar in its properties; at least when heated it melts, and gives out a very strong smell of caromel.

Oxymuriatic acid converts gum into citric acid, according to the experiments of Vauquelin. He passed a current of oxymuriatic acid gas through a diluted solution of gum in water. In a few days almost the whole of the gum was acidified; and he detected citric acid by the formation of citrat of lime, soluble in water, and decomposable by oxalic acid. If nitric acid is slightly heated upon gum till it has dissolved it, and till a little nitrous gas is exhaled, the solution on cooling deposits saclactic acid. Malic acid is formed at the same time; and if the heat is continued, the gum is at last changed into oxalic acid. Thus no less than three acids are developed by the action of nitric acid on gum. We are indebted to Mr. Cruikshank for the most precise experiments on the quantity of oxalic acid obtainable from gum by nitric acid. By digesting 480 grains of it with six ounces of nitric acid, he obtained 210 grains of oxalic acid, and six grains of oxalat of lime.

Gum is insoluble in alcohol. When alcohol is poured into mucilage, the gum immediately precipitates; because the affinity between water and alcohol is greater than that between water and gum. The gum in this case is in the state of soft opaque white flakes. Neither is gum soluble in ether. It is not soluble in oils; but when triturated with a little oil it renders the oil miscible with water.

The action of the hydrosulphurets, sulphurets, phosphurets, and of most of the salts on gum, has not been examined with any attention.

Gum and sugar readily unite together by dissolving both in water. By gentle evaporation a perfectly transparent solid substance is obtained, which does not crystallize. When treated with alcohol it becomes white, opaque, and soft. The greater part of the sugar is dissolved, and the gum remains united to a small portion. It has a sweetish taste, and very much resembles in appearance the substance of which the nests of wasps are formed.

3. When gum is distilled in a retort, the products are

water impregnated with a considerable quantity of pyromucous acid, or acetic acid combined with oil, a little empyreumatic oil, carbonic acid gas, and carbureted hydrogen gas. When the pyromucous acid obtained by the process is saturated with lime, a quantity of ammonia is disengaged with which that acid has been combined. The charcoal which remained in the retort leaves behind it, after incineration, a little lime and phosphat of lime. Mr. Cruikshank, to whom we are indebted for these facts, gradually heated 480 grains of gum arabic to redness in a coated glass retort. The products were,

Pyromucous acid mixed with some oil	210 gr.
Charcoal - - - - - - -	96
Lime and a little phosphat of lime -	10
Carbureted hydrogen and carbonic acid gas	164
Total	480.

The pyromucous acid liquid contained less acid than what was obtained from an equal weight of sugar, in the proportion of 118 to 150. The gases consisted of 93 ounce measures of carbonic acid, and 180 of carbureted hydrogen, composed of 5 parts charcoal to 1 of hydrogen. When the pyromucous acid was saturated with lime, ammonia was disengaged.

From these experiments it follows, that gum contains oxygen, hydrogen, carbon, azote, and lime. The lime may be detected by dropping nitric acid into a solution of gum; needleform crystals of sulphat of lime are slowly deposited. If we compare the products obtained by the distillation of sugar with those obtained from gum, we can scarcely doubt that the latter contains the greater proportion of carbon. As it yields less pyromucous acid, it is not improbable that it also contains less oxygen. Sugar is a triple compound; but gum contains five constituents.

4. The species of gum at present known amount to four; though it is likely that a more rigid examination of the vegetable kingdom will discover a greater number. These are gum arabic, gum tragacanth, cherry-tree gum, and the mucilage which is contained in the roots and leaves of many plants.

Gum arabic exudes from the mimosa nilotica, and other species of mimosa. It is the species described in the preceding part of this article.

5. Gum tragacanth is the produce of the astragalus tragacantha, a thorny shrub which grows in Candia and other islands of the Levant. The gum is said to exude about the end of June from the stem and larger branches, and soon dries in the sun. It is in the state of whitish verniform pieces, not nearly so transparant as gum arabic. It is much stronger than gum arabic, not so easily dissolved in water, and is said to go farther. When Mr. Cruikshank distilled 480 grains of it in a glass retort, he obtained the following products:

Pyromucous acid - - - -	245 gr.
Charcoal - - - - - - -	93
Lime with some phosphat - - -	12
Carbonic acid gas and carbureted hydrogen gas	130
	480

When the pyromucons acid was saturated with lime, a considerable greater proportion of ammonia was disengaged than from the pyromucous acid of gum arabic. The gases were 78 ounce-measures of carbonic acid, and 91 of carbureted hydrogen. Hence we see that gum tragacanth contains more azote and lime, and perhaps more oxygen and less carbon, than gum arabic.

6. The prunus avium, the common cherry and plum trees, and the almond and apricot, likewise yield a gum which exudes in great abundance from natural or artificial openings in the stem. It is of a reddish-brown colour, in large masses, and much softer and more easily melted than gum arabic. But no precise set of experiments has been made to ascertain how far its properties coincide with those of the last two species.

7. Mucilage is contained in the roots and leaves of a vast number of plants. Almost all the bulbous roots and fleshy leaves yield it. For example, the roots of the hyacinthus nondescriptus, and the althea officinalis; the leaves of the altbæra, of tbe malva sylvestris of many of the fuci, and of the greater number of the lichens; the seeds of flax, quinces, fenugrec, &c.

The bulbs of the hyacinth contain so much mucilage, that when dried they may be employed as a substitute for gum arabic. This was first made known to the public by Mr. Willis. A mucilage may be extracted from most of the stringy lichens by water, which likewise answers all the purposes of a solution of gum. This was first discovered by lord Dundonald. The mucilaginous quality of most of the fuci is apparently much greater, though the mucilage obtained from them does not answer so well.

How far the mucilage extracted by water from these plants agrees with gum in its properties, has not been examined with much precision, if we except the mucilage of the hyacinth. From the experiments of Leroux, it appears that the mucilage of that plant is in every respect the same with gum. Tbe bulbs are to be pounded, mixed with five times their weight of water, and subjected to the press. The residue is to be diluted afresh, and again pressed. The liquid thus obtained is to be allowed to repose for some days till it clarifies somewhat, and then evaporated to dryness. The gum remains.

8. It has been remarked by Mr. Barrow, and probably also by others, that all the plants which yield gum have an astringent bark. This rule, however, does not hold with respect to mucilage. Almost all the trees known to yield gum have been enumerated in the preceding part of this article. To attempt a list of all the plants containing mucilage, would, in the present state of our knowledge, be superfluous, even if it was possible. It exists most abundantly in young plants, and gradually disappears as they arrive at perfection. It forms a great proportion of the leaves and roots of many eatable plants.

9. Gum is a nutritive food, though seldom employed for that purpose, except when in the state of mucilage. It is used frequently as a paste, and to give stiffness or lustre to linen. The calico-printers use it in great quantities to give their colours such a degree of consistency as prevents them from running upon the cloth. It forms an ingredient in ink for a similar reason. In medicine it forms the base of many mixtures.

Gum-resins. This class of vegetable substances has been long distinguished by physicians and apothecaries. It contains many active substances much employed in medicine; and they certainly possess a sufficient num-

ber of peculiar properties to entitle them to be ranked apart. Unfortunately these substances have not yet attracted much of the attention of chemists. Their properties and constituents of course are but imperfectly ascertained. They may, however, be distinguished by the following characters.

They are usually opaque, or at least their transparency is inferior to that of the resins. They are always solid, and most commonly very brittle, and have sometimes a fatty appearance.

When heated they do not melt as the resins do, neither are they so combustible. Heat, however, commonly softens them, and causes them to swell. They burn with a flame. They have almost always a strong smell, which in several instances is alliaceous. Their taste also is often acrid, and always much stronger than that of the resins. They are partially soluble in water; but the solution is always opaque, and usually milky.

Alcohol dissolves only a portion of them. The solution is transparent; but when diluted with water it becomes milky; yet no precipitate falls, nor is any thing obtained by filtring the solution. Vinegar and wine likewise dissolves them partially; and the solution, like the aqueous, is opaque or milky.

The action of alkalies on them has been examined only by Mr. Hatchett. All of them tried by that celebrated chemist dissolved readily in alkaline solutions when assisted by heat. We may therefore consider them as soluble in alkalies like resins. Mr. Hatchett also found them acted on by nitric acid, and dissolved by it just as the resinous bodies.

The specific gravity is usually greater than that of the resins. Their other properties still continue unknown. They all either exude spontaneously from plants, or are obtained by incisions. At first they seem to be in a liquid state; but they gradually harden when exposed to the air and weather.

They have been usually considered by chemists as composed of gum and resin; but their properties are not consistent with that supposition. They all contain a volatile oil, or a substance intermediate between an oil and resin. To this substance we are to ascribe the milky solution which they form with water. The other constituent, in most cases, bears a much closer resemblance to extractive than to gum; perhaps, then, we shall not err very far, if we consider the gum-resins as composed of a gum or an extractive substance, and a body intermediate between oil and resin; to which last they owe their most peculiar properties.

The gum-resins which have been hitherto applied to any useful purpose are chiefly the following:

1. *Galbanum*. It is obtained from the bubon galbanum, a perennial plant, and a native of Africa. When this plant is cut across a little above the root, a milky juice flows out, which soon hardens and constitutes galbanum. It is brought from the Levant in small pieces composed of tears, agglutinated together of a yellowish or white colour. Its taste is acrid and bitter, and its smell peculiar. Water, vinegar, and wine, dissolve most of it, but the solution is milky. Alcohol acts but feebly; when distilled it yields volatile oil in considerable quantity. Its specific gravity is 1.2.

2. *Ammoniac*. This substance is brought from the East Indies. Nothing certain is known concerning the plant which yields it; though from analogy it has been suspected to be a species of ferula. It is in small pieces and has a yellowish-white colour. Its smell is somewhat like that of galbanum, but more pleasant; its taste is a nauseous sweet mixed with bitter. It does not melt. Water dissolves a portion of it; the solution is milky, but gradually lets fall a resinous portion. One-half is soluble in alcohol. It seems then to contain resin completely formed: specific gravity is 1.2. Mr. Hatchett found it soluble in alkalies.

3. *Olibanum*, is obtained from the juniperus lycia, and is chiefly collected in Arabia. It is the frankincense of the ancients; it is in transparent brittle masses about the size of a chesnut. Its colour is yellow. It has little taste; and when burnt diffuses an agreeable odour. Alcohol dissolves it; and with water it forms a milky liquid. When distilled it yields a little volatile oil. Its specific gravity is 1.173.

4. *Sagapanum*. The plant which yields this gum-resin is not well known: but it is suspected to be the ferula persica. The substance itself is brought to Europe from Alexandria. It is commonly in tears agglutinated together: colour yellow; taste hot and bitter; smell alliaceous; softens between the fingers, but does not melt when heated: sparingly soluble in water, but almost completely soluble in alcohol. When distilled it yields a volatile oil.

5. *Asafœtida*. This substance is obtained from the ferula asafœtida, a perennial plant which is a native of Persia. When the plant is about four years old, its roots are dug up and cleaned. Their extremity being then cut off, a milky juice exudes, which is collected. Then another portion is cut off, and more juice exudes. This is continued till the roots are exhausted. The juice thus collected soon hardens, and constitutes asafœtida. It is brought here in small grains of different colours, whitish, reddish, violet, brown: pretty hard, but brittle: its taste is acrid and bitter; its smell strongly alliaceous and fœtid. It is imperfectly soluble both in alcohol and water; but, like the other gum-resins, has been but carelessly analysed. Its specific gravity is 1.327.

6. *Scammony*. This substance is obtained from the convolvulus scammonia, a climbing plant which grows in Persia. The roots when cut yield a milky juice; this when collected and allowed to harden constitutes scammony. Colour, dark grey; smell, peculiar and nauseous; taste, bitter and acrid: with water it forms a greenish coloured opaque liquid. Alcohol dissolves the greatest part of it; it is usually mixed with the expressed juice of the root, and frequently also with other impurities, which alter its appearance. In medicine it operates as a strong cathartic. Its specific gravity is 1.235.

7. *Opoponax*. This substance is obtained from the pastinaca opoponax, a plant which is a native of the countries round the Levant. The gum resin, like most others, is obtained by wounding the roots of the plant. The milky juice when dried in the sun constitutes the opoponax. It is in lumps of a reddish yellow colour, and white within; smell peculiar; taste bitter and acrid; with water it forms a milky solution. Its specific gravity is 1.622.

8. *Gamboge*, or *gumgutt*. This substance is obtained from the stalagmitis cambogioides, a tree which grows

GUN

wild in the East Indies. In Siam it is obtained in drops by wounding the shoots; in Ceylon it exudes from wounds of the bark. It is brought to Europe in large cakes. Its colour is yellow; it is opaque, brittle, and breaks vitreous; it has no smell, and very little taste; with water it forms a yellow turbid liquid. Alcohol dissolves it almost completely: and when mixed with water it becomes turbid, unless the solution contains ammonia; in that case acids throw down an insoluble yellow precipitate. It operates, when taken internally, as a most violent cathartic; its specific gravity is 1.221. It appears that it was taken to Europe by the Dutch about the middle of the 17th century.

9. *Myrrh.* The plant from which this substance is obtained is unknown; if we believe Bruce, it belongs to the genus of Mimosa. It grows in Abyssinia and Arabia: it is in the form of tears; colour reddish-yellow; when pure som ewhat transparent, but it is often opaque: odour peculiar: taste bitter and aromatic: does not melt when heated, and burns with difficulty. With water it forms a yellow opaque solution: the solution in alcohol becomes opaque when mixed with water, but no precipitate appears: by distillation it yields oil: its specific gravity is 1.360; it is employed in medicine: Mr. Hatchett found it soluble in alkalies.

10. *Euphorbium.* This substance is obtained from the euphorbia officinalis. The milky juice which exudes from that plant, when dried in the sun, constitutes euphorbium: it is brought from Africa in small yellow tears; it has no smell, and is mostly soluble in alcohol: its specific gravity is 1.124. It is considered as poisonous.

11. Little is known concerning the substances called bdellium and caranna, reckoned among the gum-resins. The specific gravity of the first is 1.371, of the second 1.124. Bdellium was celebrated by the ancient physicians: it comes from Arabia. The substance extracted from ivy, and known by the name of gummi hederæ, is considered as a gum-resin. Its specific gravity is 1.294.

12. From the experiments made upon ipecacuanha, the root of the cephelis ipecacuanha, especially by Dr. Irvine, we learn that it also contains a gum-resin. The same remark applies to several other vegetable substances employed in medicine.

It deserves attention, that the gum-resins, when subjected to destructive distillation, yield all of them a portion of ammonia; a proof that they all contain azote. In this respect they agree with gum and extractives.

GUM-ELASTIC. See CAOUTCHOUC.

GUINEA, a gold coin struck in England. The value or rate of the guinea has varied. It was at first equal to 20 shillings; but by the scarcity of gold it was afterwards advanced to 21s. 6d.; though it is now sunk to 21s. The pound weight troy of gold is cut into 44 parts and a half, and each part makes a guinea, which is therefore equal to $\frac{2}{89}$lb. or $\frac{24}{89}$ oz. or 5 dwts. $9\frac{39}{89}$ gr. This coin took its name, guinea, from the circumstance of the gold of which it was at first struck being brought from that part of Africa called Guinea, for which reason also it bore the impression of an elephant.

GUN, a fire-arm, or weapon of offence, which forcibly discharges a ball or other matter through a cylindrical tube, by means of inflamed gunpowder.

The word gun now includes most of the species of fire arms; mortars and pistols being almost the only kind excepted from this denomination. They are divided into great and small guns; the former including all that are usually called cannon, ordnance, or artillery; and the latter including muskets, firelocks, carabines, musquetoons, blunderbusses, fowling-pieces, &c.

The first hint of the invention of guns is in the works of Roger Bacon, who flourished in the 13th century. In a treatise written by him about the year 1280, he proposes to apply the violent explosive force of gunpowder for the destruction of armies. And though it is certainly known that the composition of gunpowder is described by Bacon in the same work, yet the invention has usually, though improperly, been ascribed to Bartholdus Schwartz, a German monk, who it is said discovered it only in the year 1320; and the invention is related in the following manner: Schwartz having, for some purpose, pounded nitre, sulphur, and charcoal together, in a mortar, which he afterwards covered imperfectly with a stone, a spark of fire accidentally fell into the mortar, which setting the mixture on fire, the explosion blew the stone to a considerable distance. Hence it is probable that Schwartz might be taught the simplest method of applying it in war; for it rather seems that Bacon conceived the manner of using it to be by the violent effort of the flame unconfined, and which is indeed capable of producing astonishing effects. And the figure and name of mortars given to a species of old artillery, and their employment, in throwing large stone bullets at an elevation, very much favour this conjecture.

When, or by whom, guns were first made, is uncertain. It is known, however, that the Venetians used cannon at the siege of Claudia Jessa, now called Chioggia, in 1366, which were brought thither by two Germans, with some powder and leaden balls; as likewise in their wars with the Genoese in 1379. But before that, king Edward the Third made use of cannon at the battle of Cressy, in 1346, and at the seige of Calais, in 1347. Cannon were employed by the Turks at the siege of Constantinople, then in possession of the Christians, in 1394, and in that of 1452, which threw a weight of 100lb.; but they commonly burst at the first, second, or third firing. Louis the XIth had one cast at Tours, of the same size, which threw a ball from the Bastille to Charenton: one of these extraordinary cannon was taken at the siege of Dieu, in 1546, by don John de Castro, and is now in the castle of St. Julien de Borra, 10 miles from Lisbon; the length of it is 20 feet 7 inches, its diameter at the middle 6 feet 3 inches, and it threw a ball of 100lb. weight. It has neither dolphins, rings, nor button; is of an unusual kind of metal; and it has a large Indostan inscription upon it, which says it was cast in 1400.

Cannon take their names from the weight of the proper ball. Thus, a piece that discharges a cast-iron ball of 24 pounds, is called a 24-pounder; one that carries a ball of 12 pounds, is called a 12-pounder; and so of the rest, divided into the following sorts, viz.

Ship-guns, consisting of 42, 36, 32, 24, 18, 12, 9, 6, and 3 pounders.

Garrison-guns, of 42, 32, 24, 18, 12, 9, and 6 pounders.

Battering-guns, of 24, 18, and 12 pounders.

Field-pieces, of 12, 9, 6, 3, 2, $1\frac{1}{2}$, 1, and $\frac{1}{2}$ pounders.

Mortars, it is thought, have been at least as ancient as cannon. They were employed in the wars of Italy, to throw balls of red-hot iron, stones, &c. long before the invention of shells.

Mr. Malter, an English engineer, first taught the French the art of throwing shells, which they practised at the siege of Motte in 1634. The method of throwing red-hot balls out of mortars was first certainly put in practice at the siege of Stralsund in 1675 by the elector of Brandenburgh; though some say in 1653, at the siege of Bremen.

Another species of ordnance has been long in use, by the name of howitzer, which is a kind of medium as to its length, between the cannon and mortar, and is a very useful piece, for discharging either shells or large balls, which is done either at point blank, or at a small elevation.

A new species of ordnance has lately been introduced by the Carron company, and thence called a carronade, which is only a very short howitzer, and which possesses the advantage of being very light and easy to work.

The species of guns before-mentioned, are now made chiefly of cast-iron; except the howitzer, which is of brass, as well as some cannon and mortars.

Muskets were first used at the siege of Rhege, in the year 1521. The Spaniards were the first who armed part of their foot with these weapons. At first they were very heavy, and could not be used without a rest. They had matchlocks, and did execution at a great distance. On their march the soldiers carried only the rests and ammunition, having boys to bear their muskets after them. They were very slow in loading, not only from the unwieldiness of their pieces, and because they carried the ball and powder separate, but from the time it took to prepare and adjust the match; so that their fire was not near so brisk as ours is now. Afterwards a lighter matchlock musket come in use; and they carried their ammunition in bandeliers, to which were hung several little cases of wood covered with leather, each containing a charge of powder. The muskets with rests were used as late as the beginning of the civil wars in the time of Charles the First. The lighter kind succeeded them, and continued till the beginning of the present century, when they also were disused, and the troops throughout Europe armed with firelocks. These are usually made of hammered iron.

GUNDELIA, a genus of the class and order syngenesia polygamia segregata. There is scarcely any calyx; what there is, is 5-flowered; cor. tubular, male and hermaphrodite; recept. chaffy; down none. There is one species, a herb of the Levant, having the habit of a thistle.

GUNNERA, a genus of the class and order gynandria, diandria. The character is, ament. with 1-flowered scales; calyx and corolla none: germen, 2-toothed; styles 2; seed one. There is one species, a herb of the Cape.

GUNNERY, the art of charging, directing, and exploding fire-arms, as cannon, mortars, muskets, &c. to the best advantage.

Gunnery is sometimes considered as a part of the military art, and sometimes as a part of pyrotechny. To the art of gunnery too belongs the knowledge of the force and effect of gunpowder, the dimensions of the pieces, and the proportions of the powder and ball they carry, with the methods of managing, charging, pointing, spunging, &c.

The first application of gunpowder to military affairs, it seems, was made soon after the year 1300, for which the proposal of friar Bacon, about the year 1280, for applying its enormous explosion to the destruction of armies, might give the first hint; and Schwartz, to whom the invention of gunpowder has been erroneously ascribed, on account of the accident above-mentioned under the article GUN, might have been the first who actually applied it in this way.

The first species of artillery, however, which were charged with gunpowder and stone bullets of a prodigious size, were of very clumsy and inconvenient structure and weight. Thus, when Mahomet the 2d besieged Constantinople, in 1453, he battered the walls with stones of this kind, and with pieces of the calibre of 1200 pounds; which could not be fired more than four times a day.

For the last 200 years, the formation of cannon has been very little improved: the battering cannon now approved, are those that were formerly called demi-cannon, carrying a ball of 24 pounds weight; this weight having been found fully sufficient. The method also of making a breach, by first cutting off the whole wall as low as possible before its upper part is attempted to be beaten down, seems to be a considerable modern improvement in the practical part of gunnery; but the most considerable improvement in the practice, is the method of firing with small quantities of powder, and elevating the piece but a little, so that the bullet may just go clear of the parapet of the enemy, and drop into their works, called ricochet firing: for by this means the ball, coming to the ground at a small angle, and with a small velocity, does not bury itself, but bounds or rolls along a great way, destroying all before it.

The Italians were the first people that made any attempts to ascertain the theory of projectiles, which they did about the beginning of the 16th century. It was then determined, that the greatest range of a shot was when discharged at an elevation of 45 degrees; and that no part of the path described by a ball is a right line. See PROJECTILES.

Mr. Robins informs us, in the preface to his New Principles of Gunnery, that he had met with no more than four authors who had treated experimentally on this subject. The first of these is Collado, in 1642, who has given the ranges of a falconet, carrying a three-pound shot, to every point of the gunner's quadrant, each point being the 12th part, or 7 degrees and a half. But from his numbers it is manifest that the piece was not charged with its usual allotment of powder.

It is extraordinary that before Mr. Robins, there were but four authors who had treated experimentally on gunnery, and these to little purpose; but the treatise of Mr. Robins is still regarded as the foundation of the science.

The first thing considered by him, and which is indeed the foundation of all other particulars relating to gunnery, is the explosive force of gunpowder. The intensity of this force Mr. Robins ascertained in different ways. One of these is by firing the powder in the air, thus: A small quantity of the powder is placed in the upper part of a glass tube, and the lower part of the tube is immerg-

ed in water, the water being made to rise so near the top, that only a small portion of air is left in that part where the powder is placed; in this situation the communication between the upper part of the tube and the external air being closed, the powder is fired by means of a burning-glass, or otherwise; the water descends upon the explosion, and stands lower in the tube than before, by a space proportioned to the quantity of powder fired. Another was by firing the powder in vacuo, viz. in an exhausted receiver, by dropping the grains of powder upon a hot iron excluded in the receiver. For the result of these experiments, see GUNPOWDER.

Having determined the force of the gunpowder, or intensity of the agent by which the projectile is to be urged, Mr. Robins next determined the effects it will produce, or the velocity with which it will impel a shot of a given weight from a piece of ordnance of given dimensions; which is a problem strictly limited, and perfectly soluble by mathematical rules, and is in general this: Given the first force, and the law of its variation, to determine the velocity with which it will impel a given body in passing through a given space, which is the length of the bore of the gun.

In the solution of this problem, Mr. Robins assumes these two postulates, viz. 1. That the action of the powder on the bullet ceases as soon as the bullet is out of the piece; and 2d. That all the powder of the charge is fired and converted into elastic fluid before the bullet is sensibly moved from its place: assumptious which for good reasons are found to be in many cases very near the truth. It is to be noted also, that the law by which the force of the elastic fluid varies, is this; viz. that its intensity is directly as its density, or reciprocally proportional to the space it occupies, being so much the stronger as the space is less; a principle well known, and common to all elastic fluids. Upon these principles then Mr. Robins resolves this problem, by means of the 39th proposition of Newton's Principia, in a direct way, and the result is equivalent to this theorem, where the quantities are expressed by algebraic symbols; viz. the velocity of the ball

$$v = 27130 \sqrt{\frac{10a}{cd} \times \log. \frac{b}{a}}.$$

$$\text{or} = 100 \sqrt{\frac{223ad^2}{w} \times \log. \frac{b}{a}}; \text{ whence}$$

v is the velocity of the ball,
a the length of the charge of powder,
b the whole length of the bore,
c the specific gravity of the ball, or weight of a cubic foot of the same matter in ounces,
d the diameter of the bore,
w the weight of the ball in ounces.

For example. Suppose $a = 2\frac{5}{8}$ inc., $b = 45$ inc., $c = 11345$ oz. for a ball of lead, and $d = \frac{3}{4}$ inc.; then $v = 27130 \sqrt{\frac{7}{2269} \times \log. \frac{120}{7}} = 1674$ feet per second, the velocity of the ball.

Or, if the weight of the bullet be $w = 1\frac{9}{20}$ oz. $= \frac{29}{20}$ oz. Then $x = 100 \sqrt{\frac{1115 \times 189}{29 \times 32} \times \log. \frac{120}{7}} = 1674$ feet, as before,

"Having in this proposition," says Mr. Robins, "shown how the velocity, which any bullet acquires from the force of powder, may be computed upon the principles of the theory laid down in the preceding propositions; we shall next show, that the actual velocities, with which bullets of different magnitudes are impelled from different pieces, with different quantities of powder, are really the same with the velocities assigned by these computations; and consequently, that this theory of the force of powder, here delivered, does unquestionably ascertain the true action and modification of this enormous power.

"But in order to compare the velocities communicated to bullets by the explosion, with the velocities resulting from the theory by computation, it is necessary that the actual velocities with which bullets move, should be capable of being discovered, which yet is impossible to be done by any methods hitherto made public. The only means hitherto practised by others for that purpose, have been either by observing the time of the flight of the shot through a given space; or by measuring the range of the shot at a given elevation, and thence computing, on the parabolic hypothesis, what velocity would produce this range. The first method labours under this insurmountable difficulty, that the velocities of these bodies are often so swift, and consequently the time observed is so short, that an imperceptible error in that time may occasion an error in the velocity thus found, of 2, 3, 4, 5, or 600 feet in a second. The other method is so fallacious, from the resistance of the air (to which inequality the first is also liable), that the velocities thus assigned may not be perhaps the tenth part of the actual velocities sought.

"To remedy then these inconveniences, I have invented a new method of finding the real velocities of bullets of all kinds; and this to such a degree of exactness (which may be augmented too at pleasure), that in a bullet moving with a velocity of 1700 feet in 1″, the error in the estimation of it need never amount to its 500th part; and this without any extraordinary nicety in the construction of the machine."

Mr. Robins then gives an account of the machine by which he measures the velocities of the balls, which machine is simply this; viz. a pendulous block of wood suspended freely by a horizontal axis, against which block are to be fired the balls whose velocities are to be determined.

"This instrument thus fitted, if the weight of the pendulum is known, and likewise the respective distances of its centre of gravity, and of its centre of oscillation, from its axis of suspension, it will thence be known what motion will be communicated to this pendulum by the percussion of a body of a known weight moving with a know degree of celerity, and striking it in a given point; that is, if the pendulum is supposed at rest before the percussion, it will be known what vibration it ought to make in consequence of such a determined blow; and, on the contrary, if the pendulum, being at rest, is struck by a body of a known weight, and the vibration which the pendulum makes after the blow is known, the velocity of the striking body may thence be determined.

"Hence then, if a bullet of a known weight strikes the pendulum, and the vibration which the pendulum makes in consequence of the stroke is ascertained, the velocity with which the ball moved is thence to be known."

Mr. Robins then explains his method of computing velocities from experiments with this machine; which method is rather troublesome and perplexed, as well as the rules of Euler and Antoni, who followed him in this business: but a much simpler rule is given in Dr. Hutton's Tracts, vol. i. p. 119, where the experiments are explained at full length, and this rule is expressed by either of the two following formulas: $v = 5.6727cg \times \frac{p+b}{bir} \sqrt{o} = 614.58cg \times \frac{p+b}{birn}$, the velocity; where v denotes the velocity of the ball when it strikes the pendulum, p the weight of the pendulum, b the weight of the ball, c the chord of the arc described by the vibration to the radius r, g the distance below the axis of motion to the centre of gravity, o the distance to the centre of oscillation, i the distance to the point of impact, and n the number of oscillations the pendulum will perform in one minute, when made to oscillate in small arcs. The latter of these two theorems is much the easiest, both because it is free of radicals, and because the value of the radical $\sqrt{o}$, in the former, is to be first computed from the number x, or number of oscillations the pendulum is observed to make.

Soon after the first publication of Robins's New Principles of Gunnery, in 1742, the learned in several other nations, treading in his steps, repeated and farther extended the same subject, sometimes varying and enlarging the machinery; particular Euler in Germany, D'Antoni in Italy, and Messrs. D'Arcy and Le Roy in France: but most of these, like Mr. Robins, with small fire-arms, such as muskets and fusils.

But in the year 1775, in conjunction with several able officers of the Royal Artillery, and other ingenious gentlemen, Dr. Hutton undertook a course of experiments with the ballistic pendulum, in which the machinery was extended to cannon-shot of 1, 2, and 3 pounds weight. An account of these was published in the Philos. Trans. for 1778, "and for which," says the Dr., "the Royal Society honoured me with the prize of the gold medal. These were the only experiments that I know of which had been made with cannon-balls for this purpose, although the conclusions to be deduced from such, are of the greatest importance to those parts of natural philosophy which are dependant on the effects of fired gunpowder; nor do I know of any other practical method of ascertaining the initial velocities within any tolerable degree of the truth. The knowledge of this velocity is of the utmost consequence in gunnery; by means of it, together with the law of the resistance of the medium, every thing is determinable relative to that business; for, besides its being an excellent method of trying the strength of different sorts of powder, it gives us the law relative to the different quantities of powder, to the different weights of shot, and to the different lengths and sizes of guns. Besides these, there does not seem to be any thing wanting to answer any inquiry that can be made concerning the flight and ranges of shot, except the effects arising from the resistance of the medium. In these experiments the weights of the pendulums employed were from 300 to near 600 pounds." In that paper is described the method of constructing the machinery, of finding the centres of gravity and oscillation of the pendulum, and of making the experiments, which are all set down in the form of a journal, with all the minute and concomitant circumstances; as also the investigation of the new and easy rule, set down just above, for computing the velocity of the ball from the experiments. The charges of powder were varied from 2 to 8 ounces, and the shot from 1 to near 3 pounds. And from the whole were clearly deduced these principal inferences: viz.

"1. First, That gunpowder fires almost instantaneously. 2. That the velocities communicated to balls or shot, of the same weight, by different quantities of powder, are nearly in the subduplicate ratio of those quantities; a small variation, in defect, taking place when the quantities of powder became great. 3d. And when shot of different weights are employed, with the same quantity of powder, the velocities communicated to them are nearly in the reciprocal subduplicate ratio of their weights. 4. So that, universally, shot which are of different weights, and impelled by the firing of different quantities of powder, acquire velocities which are directly as the square roots of the quantities of powder, and inversely as the square roots of the weights of the shot, nearly. 5. It would therefore be a great improvement in artillery, to make use of shot of a long form, or of heavier matter; for thus the momentum of a shot, when fired with the same weight of powder, would be increased in the ratio of the square root of the weight of the shot. 6. It would also be an improvement to diminish the windage; for by so doing, one-third or more of the quantity of powder might be saved. 7. When the improvements mentioned in the last two articles are considered as both taking place, it is evident that about half the quantity of powder might be saved, which is a very considerable object. But important as this saving may be, it seems to be still exceeded by that of the article of the guns; for thus a small gun may be made to have the effect and execution of another two or three times its size in the present mode, by discharging a shot of two or three times the weight of its natural ball or round shot. And thus a small ship might discharge shot as heavy as those of the greatest now made use of.

"Finally, as the above experiments exhibit the regulations with regard to the weights of powder and balls, when fired from the same piece of ordnance, &c.; so by making similar experiments with a gun, varied in its length, by cutting off from it a certain part before each course of experiments, the effects and general rules for the different lengths of guns may be certainly determined by them. In short, the principles on which these experiments were made, are so fruitful in consequences, that, in conjunction with the effects resulting from the resistance of the medium, they seem to be sufficient for answering all the inquiries of the speculative philosopher, as well as those of the practical artillerist."

GUNPOWDER, a composition of nitre, sulphur, and charcoal, mixed together, and usually granulated.

It appears that Roger Bacon knew of gunpowder. He tells us, in his Treatise De Secretis Operibus Artis et Naturæ, et de Nullitate Magiæ, cap. 6, which is supposed by some to have been published at Oxford in 1216, "that from saltpetre and other ingredients, we are able to make a fire that shall burn at what distance we please." And Dr. Plott, in his History of Oxfordshire, p. 236,

assures us that these "other ingredients were explained in a MS. copy of the same treatise, in the hands of Dr. G. Langbain, and seen by Dr. Wallis, to be sulphur and wood-coal."

As to the preparation of gunpowder, there are various compositions of it, with respect to the proportions of the three ingredients, to be met with in pyrotechnical writings; but the process of making it up is much the same in all.

For some time after the invention of artillery, gunpowder was of a much weaker composition than that now is use. But when guns of modern structure were introduced, gunpowder of the same composition as the present came also into use. In the time of Tartaglia the cannon-powder was made of 4 parts of nitre, one of sulphur, and one of charcoal: and the musket-powder of 48 parts of nitre, 7 parts of sulphur, and 8 parts of charcoal; or of 18 parts of nitre, 2 parts of sulphur, and 3 parts of charcoal; the modern composition is,

76	parts nitre
15	charcoal
9	sulphur
100	

These ingredients are first reduced to a fine powder separately, then mixed intimately, and formed into a thick paste with water. After this has dried a little, it is placed upon a kind of sieve full of small holes, through which it is forced. By that process it is divided into grains, the size of which depends upon the size of the holes through which they have been squeezed. The powder, when dry, is put into barrels, which are made to turn round on their axes. By this motion the grains of gunpowder rub against each other, their asperities are worn off, and their surfaces are made smooth. The powder is then said to be glazed.

Gunpowder, as is well known, explodes violently when a red heat is applied to it. This combustion takes place even in a vacuum; a vast quantity of gas is emitted, the sudden production of which is the cause of all the violent effects which this substance produces. Their combustion is evidently owing to the decomposition of the nitre by the charcoal and sulphur. The products are carbonic acid gas, azotic gas, sulphurous acid gas, and probably sulphureted hydrogen. Mr. Cruikshank has ascertained that no perceptible quantity of water is formed. What remains after the combustion is potass combined with a small portion of carbonic acid, sulphat of potass, a very small proportion of sulphuret of potass, and unconsumed charcoal. This mixture soon attracts moisture, and the sulphuret which it contains enables it to act strongly on metallic bodies.

To make gunpowder duly, regard is to be had to the purity or goodness of the ingredients, as well as the proportions of them; for the strength of the powder depends much on that circumstance, and also on the due working or mixing of them together.

To purify the nitre, by taking away the fixt or common salt, and earthy part. Dissolve it in a quantity of hot water over the fire; then filtrate it through a flannel bag, into an open vessel, and set it aside to cool, and to crystallize. These crystals may in like manner be dissolved and crystallized again; and so on, till they become quite pure and white. Then put the crystals into a dry kettle over a moderate fire, which gradually increase till it begins to smoke, evaporate, lose its humidity, and grow very white: it must be kept continually stirring with a ladle, lest it should return to its former figure, by which its greasiness would be taken away; after that, so much water is to be poured into the kettle as will cover the nitre; and when it is dissolved, and reduced to the consistency of a thick liquor, it must be continually stirred with a ladle till all the moisture is again evaporated, and it is reduced to a dry and white meal.

The like regard is to be had to the sulphur; choosing that which is in large lumps, clear and perfectly yellow; not very hard, nor compact, but porous; nor yet too much shining; and if, when set on fire, it freely burns all away, it is a sign of its goodness; so likewise, if it is pressed between the two iron plates that are hot enough to make it run, and in the running appear yellow, and that which remains of a reddish colour, it is then fit for the purpose. But in case it is foul, it may be purified in this manner; melt the sulphur in a large iron ladle or pot, over a very gentle coal-fire, well kindled, but not flaming; then scum off all that rises on the top, and swims upon the sulphur; take it presently after from the fire, and strain it through a double linen cloth, letting it pass leisurely; so will it be pure, the gross matter remaining behind in the cloth.

For the charcoal, the third ingredient, such should be chosen as is large, clear, and free from knots, well burnt, and cleaving. The charcoal of light woods is mostly preferred, as of willow, and that of the branches or twigs of a moderate thickness, as of an inch or two in diameter. Dogwood is now much esteemed for this purpose. And a method of charring the wood in a large iron cylinder has lately been recommended, and indeed proved, as yielding better charcoal than formerly.

The charcoal not only concurs with the sulphur in supplying the inflammable matter, which causes the detonation of the nitre, but also greatly adds to the explosive power of it by the quantity of carbonic acid gas, expelled during its combustion.

These three ingredients, in their purest state, being procured, long experience has shown that they are then to be mixed together in the proportion before-mentioned, to have the best effect.

But it is not the due proportion of the materials only, which is necessary to the making of good powder; another circumstance, not less essential, is the mixing them well together; if this is not effectually done, some parts of the composition will have too much nitre in them, and others too little; and in either case there will be a defect of strength in the powder.

After the materials have been reduced to fine dust, they are mixed together, and moistened with water, or vinegar, or urine, or spirit of wine, &c. and then beaten together with wooden pestles for 24 hours, either by hand, or by mills, and afterwards pressed into a hard, firm, solid cake. When dry, it is grained or corned, which is done by breaking the cake of powder into small pieces, and so running it through a sieve; by which means the grains may have any size given them, according to the nature of the sieve employed, either finer or coarser; and thus also the dust is separated from the grains, and again

mixed with other manufacturing powder, or worked up into cakes again.

Powder is smoothed, or glazed, as it is called, for small arms, by the following operation: a hollow cylinder or cask is mounted on an axis, turned by a wheel; this cask is half-filled with powder, and turned for six hours; and thus by the mutual friction of the grains of powder it is smoothed, or glazed. The fine mealy part, thus separated or worn off from the rest, is again granulated.

The nature, effects, &c. of powder. When the powder is separated as above, if the least spark is struck upon it from a steel and flint, the whole will immediately inflame, and burst out with extreme violence. The effect is not hard to account for: the charcoal part of the grain upon which the spark falls, catching fire like tinder, the sulphur and nitre are readily melted, and the former also breaks into flame; the contiguous grains at the same time undergoing the same fate.

The explosion of gun-powder therefore arises from the violent action, by which all the mixture being quickly and vehemently heated, is rarefied and converted into gas and vapour; which vapour, by the violence of that action becoming so hot as to shine, appears in the form of a flame.

To understand the force of gunpowder, it must be considered that, whether it is fired in a vacuum or in air, it produces by its explosion permanently elastic fluids. It also appears from experiment, that the elasticity or pressure of the fluids produced by the firing of gunpowder is, cæteris paribus, directly as its density.

To determine the elasticity and quantity of the elastic fluids produced from the explosion of a given quantity of gunpowder, Mr. Robins premises, that the elasticity of the fluids increases by heat, and diminishes by cold, in the same manner as that of the air; and that the density of this fluid, and consequently its weight, are the same with the weight of an equal bulk of air, having the same elasticity and the same temperature. From these principles, and from the experiments by which they are established, he concludes that the fluid produced by the firing of gunpowder is nearly three-tenths of the weight of the generating powder itself; and that the volume or bulk of this air or fluid, when expanded to the rarity of common atmospheric air, is about 244 times the bulk of the powder.

Hence it appears, that any quantity of powder fired in any confined space, which it adequately fills, exerts at the instant of its explosion against the sides of the vessel containing it, and the bodies it impels before it, a force at least 244 times greater than the elasticity of common air, or, which is the same thing, than the pressure of the atmosphere; and this without considering the great addition arising from the violent degree of heat with which it is endued at that time; the quantity of which augmentation is the next head of Mr. Robins's inquiry. He determines that the elasticity of the air is augmented in a proportion somewhat greater than that of 4 to 1, when heated to the extremest heat of red-hot iron; and supposing that the flame of fired gunpowder is not of a less degree of heat, increasing the former number a little more than four times, makes nearly 1000; which shows that the elasticity of the flame, at the moment of explosion, is about 1000 times stronger than the elasticity of common air, or than the pressure of the atmosphere. But, from the height of the barometer, it is known that the pressure of the atmosphere upon every square inch, is on a medium $14\frac{3}{4}$lb.; and therefore 1000 times this, or 14750lb. is the force or pressure of the flame of gunpowder, at the moment of explosion, upon a square inch, which is very nearly equivalent to six tons and a half.

This great force, however, disminishes as the fluid dilates itself, and in that proportion, viz. in proportion to the space it occupies, it being only half the strength when it occupies a double space, one-third the strength when triple the space, and so on.

Mr. Robins farther supposes the degree of heat abovementioned to be a kind of medium heat; but that in the case of large quantities of powder the heat will be higher, and in very small quantities lower; and that therefore in the former case the force will be somewhat more, and in the latter somewhat less, than 1000 times the force of the atmosphere.

He farther found that the strength of powder is the same in all variations in the density of the atmosphere, but that the moisture of the air has a great effect upon it; for the same quantity which in a dry season would discharge a bullet with a velocity of 1700 feet in one second, will not in damp weather give it a velocity of more than 12 or 1300 feet in a second, or even less, if the powder is bad, and negligently kept. Farther, as there is a certain quantity of water which, when mixed with powder, will prevents its firing at all, it cannot be doubted that every degree of moisture must abate the violence of the explosion; and hence the effects of damp powder are not difficult to account for.

It is to be observed, that the moisture imbibed by powder does not render it less active when dried again. Indeed, if powder is exposed to very great damps without any caution, or when common salt abounds in it, as often happens through negligence in refining the nitre, in such cases the moisture it embibes may perhaps be sufficient to dissolve some part of the nitre; which is a permanent damage that no drying can retrieve. But when tolerable care is taken in preserving powder, and the nitre it is composed of has been well purged from common salt, it will retain its force for a long time; and it is said that powder has been known to have been preserved for 50 years without any apparent damage from its age.

The velocity of expansion of the flame of gunpowder, when fired in a piece of artillery, without either bullet or other body before it, is prodigiously great, viz. 7000 feet per second, or upwards, as appears from the experiments of Mr. Robins. But Mr. Bernouilli and Mr. Euler suspect it is still much greater. Perhaps, indeed, it may not be less, at the moment of explosion, than four times as much.

It is this prodigious celerity of expansion of the flame of fired gunpowder, which is its peculiar excellence, and the circumstance in which it so eminently surpasses all other inventions, either ancient or modern; for as to the momentum of these projectiles only, many of the warlike machines of the ancients produced in this a degree far surpassing that of our heaviest cannon-shot or shells; but the great celerity given to these bodies cannot be in the least approached by any other means but the flame of powder. The best means of proving gunpowder

is that of the pendulum, already described under the article GUNNERY.

To recover damaged powder. The method of the powder-merchants is this: they put part of the powder on a sailcloth, to which they add an equal weight of what is really good; then with a shovel they mingle it well together, dry it in the sun, and barrel it up, keeping it in a dry and proper place.

Others again, if it is very bad, restore it by moistening it with vinegar, water, urine, or brandy; then they beat it fine, sift it, and to every pound of powder add an ounce, or an ounce and a half, or two ounces (according as it is decayed), of melted nitre; and afterwards these ingredients are to be moistened and well mixed, so that no particular substance may be discerned: which may be known by cutting the mass, and then they granulate it as usual.

In case the powder is quite spoiled, the only thing to be done is to extract the salt-petre with water, in the usual way, by boiling, filtrating, evaporating, and crystallizing; and then, with fresh sulphur and charcoal, to make it up afresh.

GUNPOWDER *and combustibles, laws concerning.* No person shall make gunpowder but in the regular manufactories established at the time of making the stat. 12 Geo. III. c. 61. or licensed by the sessions, pursuant to certain provisions, under forfeiture of the gunpowder, and 2*s.* per lb. nor are pestle-mills to be used under a similar penalty.

Only 40 lbs. of powder to be made at one time under one pair of stones, except Battle-powder, made at Battle and elsewhere in Sussex.

Not more than 40 cwt. to be dried at one time in one stove; and the quantity only required for immediate use to be kept in or near the place of making, except in brick or stone magazines, 50 yards at least from the mill.

Not more than 25 barrels to be carried in any land carriage, nor more than 200 barrels by water, unless going by sea or coastwise, each barrel not to contain more than 100lbs.

No dealer to keep more than 200lbs. of powder, nor any person not a dealer, more than 50lbs. in the cities of London and Westminister, or within three miles thereof, or within any other city, borough, or market-town, or one mile thereof, or within two miles of the king's palaces or magazines, or half a mile of any parish-church, on pain of forfeiture; and 2*s.* per lb. except in licensed mills, or to the amount of 300 lbs. for the use of collieries, within 200 yards of them.

GUN-SMITHERY, the business of a gun-smith or the art of making fire-arms of the smaller sort, as muskets, fowling-pieces, pistols, &c. The principal part of these instruments is the barrel, which ought to have the following properties: 1. Lightness, that it may incommode the person who carries it as little as possible. 2. Sufficient strength, and other properties requisite to prevent its bursting by a discharge. 3. It ought to be constructed in such a manner as not to recoil with violence. And, 4. it ought to be of sufficient length to carry the shot to as great a distance as the force of the powder employed is capable of doing.

The manufacture of fire-arms is now carried to such a degree of perfection by different European nations, that it may perhaps be justly doubted whether any farther improvement in the requisites just mentioned can be made. For the materials the softest iron that can be procured is to be employed. The best in this country are formed of stubs, as they are called, or old horse-shoe nails; which are procured by gun-smiths from farriers, and from poor people who subsist by picking them up on the great roads leading to London. These are sold at about ten shillings per cwt. and 28 pounds are requisite to form a single musket-barrel. The method of manufacturing them from this material is as follows: A hoop of about an inch broad, and six or seven inches diameter, is placed in a perpendicular situation, and the stubs, previously well cleaned, piled up in it with their heads outermost on each side, till the hoop is quite filled and wedged tight with them. The whole then resembles a rough circular cake of iron; which being heated to a white heat, and then strongly hammered, coalesces into one solid lump. The hoop is now removed, and the beatings and hammerings repeated till the iron is rendered very tough and close in the grain; when it is drawn out into pieces of about 24 inches in length, half an inch or more in breadth, and half an inch in thickness. It is, however, not easy to conceive how old stubs can be procured sufficient to supply iron for the number of barrels which go under this denomination. Nor do we, upon any principles of science, see any farther advantage to be derived from this manufacture, than that nail-iron is generally the best of iron, and well hammered.

Four of the pieces, prepared as has been described, are required for one barrel; but in the ordinary way a single bar of the best soft iron is employed. The workmen begin with hammering out this into the form of a flat ruler, having its length and breadth proportioned to the dimensions of the intended barrel. By repeated heating and hammering this plate is turned round a tempered iron-rod called a mandril, the diameter of which is considerably smaller than the intended bore of the barrel. One of the edges of the plate being laid over the other about half an inch, the whole is heated and welded by two or three inches at a time, hammering it briskly, but with moderate strokes, upon an anvil which has a number of semicircular furrows in it, adapted to the barrels of different sizes. Every time the barrel is withdrawn from the fire, the workman strikes it gently against the anvil once or twice in an horizontal direction. By this operation the particles of the metal are more perfectly consolidated, and every appearance of a seam in the barrel is obliterated. The mandril being then again introduced into the cavity of the barrel, the latter is very strongly hammered upon it in one of the semicircular hollows of the anvil, by small portions at a time; the heatings and hammerings being repeated until the whole barrel has undergone the operation, and its parts rendered as perfectly continuous as if they had been formed out of a solid piece. To effect this completely, three welding heats are necessary when the very best iron is made use of, and a greater number for the coarser kinds. The French workmen imagine that by giving the barrel, while in the fire, slight horizontal strokes with the hammer, so as to communicate a vibratory motion to the iron, those particles are thrown off which are in a state of fusion, and cannot easily be con-

verted into malleable iron: but considering the great number of operations already described which the metal has undergone, we can scarcely suppose this to be of much consequence.

The next operation in forming the barrels is the boring of them, which is done in the following manner: Two beams of oak, each about six inches in diameter, and six or seven feet long, are placed horizontally, and parallel to one another; having each of their extremities mortised upon a strong upright piece about three feet high, and firmly fixed. A space of three or four inches is left between the horizontal pieces, in which a piece of wood is made to slide by having at either end a tenon let into a groove which runs on the inside of each beam throughout its whole length. Through this sliding piece a strong pin or bolt of iron is driven or screwed in a perpendicular direction, having at its upper end a round hole large enough to admit the breech of the barrel, which is secured in it by means of a piece of iron that serves as a wedge, and a vertical screw passing through the upper part of the hole. A chain is fastened to a staple in one side of the sliding piece which runs between the two horizontal beams; and passing over a pulley at one end of the machine, has a weight hooked on to it. An upright piece of timber is fixed above this pulley, and between the ends of the beams, having its upper end perforated by the axis of an iron crank furnished with a square socket; the other axis being supported by the wall, or by a strong post, and loaded with a heavy wheel of cast iron to give it force. The axes of this crank are in a line with the hole in the bolt already mentioned. The borer being then fixed into the socket of the crank, has its other end, previously well oiled, introduced into the barrel, whose breech part is made fast in the hole of the bolt: the chain is then carried over the pulley, and the weight hooked on; the crank being then turned with the hand, the barrel advances as the borer cuts its way, till it has passed through the whole length. The boring bit consists of an iron-rod somewhat longer than the barrel, one end of which fits the socket of the crank; the other is adapted to a cylindrical piece of tempered steel, about an inch and a half in length, having its surface cut after the manner of a perpetual screw, with five or six threads, the obliquity of which is very small. The breadth of the furrows is the same with that of the threads, and their depth sufficient to let the metal cut by the threads pass through them easily. Thus the bit gets a strong hold of the metal; and the threads, being sharp at the edges, scoop out and remove all the inequalities and roughness from the inside of the barrel, and render the cavity smooth and equal throughout. A number of bits, each a little larger than the former, are afterwards successively passed through the barrel in the same way, until the bore has acquired the magnitude intended. By this operation the barrel is very much heated, especially the first time the borer is passed through it, by which means it is apt to warp. To prevent this in some measure, the barrel is covered with a cloth kept constantly wetted, which not only preserves the barrel from an excess of heat, but likewise preserves the temper of the bit from being destroyed. The borer itself must also be withdrawn from time to time; both to clean it from the shavings of the metal and to oil it, or repair any damages it may have sustained. Every time a fresh bit has been passed through the barrel, the latter must be carefully examined, to see if it has warped: and likewise if there are any spots, by the workmen called *blacks*, on its inside. When warped, it must be straightened on the anvil, for which a few slight strokes on the convex parts will be sufficient; and this is termed *setting-up* the barrel. When black spots are perceived, the corresponding part on the outside must be marked, and driven in by gentle strokes with the hammer, when they will be completely removed by passing the borer another time through the piece.

The equality of the bore is of the utmost consequence to the perfection of a barrel; insomuch that the greatest possible accuracy in every other respect will not make amends for any deficiency in this. The method used by gunsmiths to ascertain this is by a cylindrical plug of tempered steel highly polished, about an inch in length, and fitting the bore exactly. This is screwed upon the end of an iron-rod, and introduced into the cavity of the barrel, where it is moved backwards and forwards; and the places where it passes with difficulty being marked, the boring bit is repeatedly passed until it moves with equal ease through every part. Any person who wishes to know the merit of his piece in this respect, may do it with tolerable accuracy by means of a plug of lead cast on a rod of iron; or even by a musket-ball filed exactly to the bore, and pushed through the barrel by a ramrod; taking care, however, not to use much force lest the ball be flattened, and its passage thus rendered difficult.

The first tool employed in forming the breech-screw is a plug of tempered steel, somewhat conical, with the threads of a male screw upon its surface, and by the workmen termed a *screw-tap*. This being introduced into the barrel, and worked from left to right and back again, until it has marked out the first four threads of the screw, another less conical tap is introduced: and when this has carried the impression of the screw as far as it is intended to go, a third one, nearly cylindrical, is made use of, scarcely differing from the plug of the breech intended to fill the screw thus formed in the barrel. The plug itself has its screw formed by means of a screw-plate of tempered steel, with several female screws, corresponding with the taps employed for forming that in the barrel. Seven or eight threads are a sufficient length for a plug; they ought to be neat and sharp, so as completely to fill the turns made in the barrel by the tap. The breech-plug is then to be case-hardened, or to have its surface converted into steel, by covering it with shavings of horn, or the parings of the hoofs of horses, and keeping it for some time red-hot, after which it is plunged in cold water.

Thus the common barrels, for the purpose especially of sporting, are made; but there are some other methods of manufacture, by which the barrels are made to differ in some respects from those just described, and are thought to be considerably improved. One kind of these are called *twisted* barrels; and by the English workmen are formed out of the plates made of *stubs*, as above described. Four of these, of the size already mentioned, are requisite to make one barrel. One of them, heated red-hot for five or six inches, is turned like a corkscrew, by means of the hammer and anvil; the remaining parts be-

ing treated successively in the same manner until the whole is turned into a spiral, forming a tube, the diameter of which corresponds with the bore of the intended barrel. Four are generally sufficient to form a barrel of the ordinary length, *i. e.* from 32 to 38 inches: and the two which form the breech or strongest part, called the *reinforced part,* are considerably thicker than those which form the muzzle, or fore part of the barrel. One of these tubes is then welded to a part of an old barrel to serve as an handle; after which the turns of the spiral are united by heating the tube two or three inches at a time to a bright white heat, and striking the end of it several times against the anvil in a horizontal direction with considerable strength, which is called *jumping the barrel;* and the heats given for this purpose are called *jumping heats.* The next step is to introduce a mandril into the cavity, and to hammer the heated portion lightly, in order to flatten the ridges or burrs raised by the jumping at the place where the spirals are joined. As soon as one piece is jumped throughout its whole length, another is welded to it, and treated in the same manner, until the four pieces are united, when the part of the old barrel is cut off, as being no longer of any use. The welding is repeated three times at least, and is performed exactly in the same manner as directed for plain barrels; and the piece may afterwards be finished according to the directions already given.

The advantages of twisted barrels are, after all, somewhat problematical; where there is so much of welding, and that in a spiral form, the welding is more likely to be done in a careless manner, or with some imperfection in some part, than when it is a plain and obvious business: nor have we observed that twisted barrels are less liable to burst than plain ones, where the latter have been well and carefully forged.

The Spanish barrels have been long held in great estimation; yet as the Spanish iron is universally allowed to be unusually good, it is probable that the superiority of their barrels is owing more to the goodness of the materials than to the skill of the workmen. It must be observed, however, that instead of making the plates overlap *a little* in the place where they join, they give one of them a complete turn; so that every Spanish barrel may be said to be double throughout its whole length. The different portions of the iron are also forged in such a manner, that the grain of the iron is disposed in a spiral manner; whence it has the same effect with a ribbon or twisted barrel. The outside is finished by turning them in a lathe; whence probably they are always less elegantly wrought than the French and English pieces. The great value put upon them is also thought to be more owing to fancy than to any real good qualities they possess. Formerly they were made from three to three feet and a half long; their bore being such as to admit a bullet from 22 to 24 in the pound, and their weight from three to three pounds and a half. The reinforced part extends two-fifths of the length; and at 10 or 12 inches from the breech is placed a sight, such as is usually put upon rifle-barrels, or those intended only for ball. According to Espinas, arquebuss-bearer to Philip IV. the weight of a Spanish barrel ought to be four pounds and a half when the length is 42 inches; but both in weight and length they are now much reduced, and seldom exceed the dimensions already mentioned.

The principal imperfections to which gun-barrels are liable, are the chink, crack, and flaw. The first is a small rent in the direction of the length of the barrel; the second across it; and the third is a kind of scale or small plate adhering to the barrel by a narrow base, from which it spreads out like the head of a nail from its shank, and when separated, leaves a pit or hollow in the metal. The chink or flaw are of much worse consequence than the crack in fire-arms, the force of the powder being exerted more upon the circumference than the length of the barrel. The flaw is much more frequent than the chink, the latter scarcely ever occurring but in plain barrels formed out of a single plate of iron, and then only when the metal is deficient in quality. When flaws happen on the outside they are of no great consequence; but in the inside they are apt to lodge moisture and foulness which corrode the iron, and thus the cavity enlarges continually till the piece bursts. This accident, however, may arise from many other causes besides the defect of the barrel itself. The best pieces will burst when the ball is not sufficiently rammed home, so that a space is left between it and the powder. A very small windage or passage for the inflamed powder between the sides of the barrel and ball will be sufficient to prevent the accident; but if the ball has been forcibly driven down with an iron ramrod, so as to fill up the cavity of the barrel very exactly, the piece will almost certainly burst, if only a very small space is left between it and the powder; and the greater the space is, the more certainly does the event take place. A piece will frequently burst from having its mouth stopped up with earth or snow; which accident sometimes happens to sportsmen in leaping a ditch, in which they have assisted themselves with their fowling-piece, putting the mouth of it to the ground; and when this did not happen, it is only to be accounted for from the stoppage being extremely slight. For the same reason a musket will certainly burst if it is fired with the muzzle immersed only a very little way in water. It will also burst from an overcharge; but when such an accident happens in other circumstances, it is most probably to be attributed to a defect in the workmanship, or in the iron itself. These defects are principally an imperfection in the welding, a deep flaw having taken place, or an inequality in the bore; which last is the most common of any, especially in the low-priced barrels. The reason of a barrel's bursting from an inequality in the bore is, that the elastic fluid, set loose by the inflammation of the powder, and endeavouring to expand itself in every direction, being repelled by the stronger parts, acts with additional force against the weaker ones, and frequently bursts through them, which it would not have done had the sides been equally thick and strong throughout. With regard to defects arising from the bad quality of the iron, it is impossible to say any thing certain. As the choice of the materials depends entirely on the gunsmith, the only way to be assured of having a barrel made of proper metal is to purchase it from an artist of known reputation, and to give a liberal price for the piece.

The recoil of a piece becomes an object of importance only when it is very great; for every piece recoils in some degree when it is discharged. The most frequent cause of an excessive recoil is an inequality in the bore of the barrel; and by this it will be occasioned even when the

inequality is too small to be perceived by the eye. The explanation of this upon mechanical principles indeed is not very easy: for as it is an invariable law, that action and reaction are equal to one another, we should be apt to suppose that every time a piece is discharged it should recoil with the whole difference between the velocity of the bullet and that of the inflamed powder. The cause to which too great a recoil in muskets has been usually attributed, is the placing of the touch-hole at some distance from the breech-plug; so that the powder is fired about the middle, or towards its fore part, rather than at its base. To avoid this some artists form a groove or channel in the breech-plug as deep as the second or third turn of the screw; the touch-hole opening into this channel, and thus firing the powder at its very lowest part. It appears, however, from a number of experiments made upon this subject by M. le Clerc, that it made very little difference with regard to the recoil, whether the touch-hole was close to the breech, or an inch distant from it. The only circumstance to be attended to with respect to its situation therefore is, that it be not quite close to the breech-plug: as in such a case it is found to be more apt to be choked up than when placed about a quarter of an inch from it.

The only other circumstance now to be determined with regard to musket-barrels is their proper length. Formerly it was supposed that the longer they were made, the greater would be the distance to which they carried the shot, and that without any limitation. This opinion continued to prevail till about half a century ago, when it was first proposed as a doubt whether long barrels carried farther than short ones. With regard to cannon, indeed, it had long before this time been known that they might be made too long; and Balthazar Killar, a celebrated cannon-founder in the reign of Louis XIV. was able to account for it. When asked by Mons. Suriry de St. Remy, why the culverin of Nancy, which is 22 feet long, did not carry a ball equally far with a shorter piece, he replied, that "the powder, when inflamed, ought to quit the cavity of the piece in a certain time, in order to exert its whole force upon the bullet; by a longer stay part of the force is lost; and the same cause may produce an inequality in the shots, by giving a variation to the bullet, so as to destroy its rectilineal course, and throw it to one side or other of the mark." Mr. Robins informs us, that "if a musket-barrel, of the common length and bore, is fired with a leaden bullet and half its weight of powder, and if the same barrel is afterwards shortened one-half, and fired with the same charge, the velocity of the bullet in this shortened barrel will be about one-sixth less than what it was when the barrel was entire; and if, instead of shortening the barrel, it is increased to twice its usual length, when it will be near eight feet long, the velocity of the bullet will not be augmented more than one-eighth part. And the greater the length of the barrel is in proportion to the diameter of the bullet, and the smaller the quantity of powder, the more inconsiderable will these alterations of velocity be." From these considerations it appears, that the advantages gained by long barrels are by no means equivalent to the disadvantages arising from the weight and incumbrance of using them; and from a multitude of experiments it is now apparent, that any one may choose what length he pleases, without any sensible detriment to the range of his piece. The most approved lengths are from 30 to 36 inches.

An opinion has generally prevailed among sportsmen, that by some unknown manœuvre the gunsmith is able to make a piece, loaded with small shot, throw the contents so close together, that even at the distance of 40 or 50 paces the whole will be confined within the breadth of a hat. From such experiments as have been made on this subject, however, it appears, that the closeness or wideness with which a piece throws its shot is liable to innumerable variations from causes which no skill in the gunsmith can possibly reach. So variable are these causes, that there is no possibility of making the same piece throw its shot equally close twice successively. In general, however, the closer the wadding is, the better disposed the shot seems to be to fall within a small compass. In firing with small shot a curious circumstance sometimes occurs, viz. that the grains, instead of being equally distributed over the space they strike, are thrown in clusters of 10, 12, 15, or more; whilst several considerable spaces are left without a grain in them. Sometimes one-third or one-half of the charge will be collected into a cluster of this kind; nay, sometimes, though much more rarely, the whole charge will be collected into one mass, so as to pierce a board near an inch thick at the distance of 40 or 45 paces. Small barrels are said to be more liable to this clustering than large ones; and M. de Marolles informs us, that this is especially the case when the barrels are new, and likewise when they are fresh-washed; though he acknowledges that it did not always happen with the barrels he employed even after they were washed. It is probable, therefore, that the closeness of the shot depends on some circumstance relative to the wadding rather than to the mechanism of the barrel.

Gun-shot wounds are attended with much worse consequences than wounds made by sharp instruments; for the parts are more shattered and torn, especially when the shot falls upon the joints, bones, or any considerable part. See Surgery.

GUNTER'S Chain, the chain in common use for measuring land, according to the true or statute measure; so called from Mr. Gunter, its reputed inventor.

The length of the chain is 66 feet, or 22 yards, or four poles of five yards and a half each; and it is divided into 100 links, of 7.92 inches each.

This chain is the most convenient of any thing for measuring land, because the contents thence computed are so easily turned into acres. The reason of which is, that an acre of land is just equal to 10 square chains, or 10 chains in length and one in breadth, or equal to 100,000 square links. Hence the dimensions being taken in chains, and multiplied together, it gives the content in square chains; which therefore being divided by 10, or a figure cut off for decimals, brings the content to acres: after which the decimals are reduced to roods and perches, by multiplying by 4 and 40. But the better way is to set the dimensions down in links as integers, considering each chain as 100 links; then, having multiplied the dimensions together, producing square links, divide these by 100,000, that is, cut off five places for

decimals, the rest are acres, and the decimals are reduced to roods and perches as before.

Ex. Suppose, in measuring a rectangular piece of ground, its length be 795 links,
and its breadth 480 links,

63600
3180

Ac. 3.81600
4

Ro. 3.264
40

Per. 10.560

So the content is 3 acres 3 roods 10 perches.

GUNTER'S LINE, a logarithmic line, usually graduated upon scales, sectors, &c.

It is also called the line of lines, and line of numbers; being only the logarithms graduated upon a ruler, which therefore serves to solve problems instrumentally in the same manner as logarithms do arithmetically. It is usually divided into a hundred parts, every tenth of which is numbered, beginning with 1, and ending with 10; so that if the first great division, marked 1, stand for one-tenth of any integer, the next division, marked 2, will stand for two-tenths; 3, three-tenths, and so on; and the intermediate divisions will, in like manner, represent 100 parts of some integer. If each of the great divisions represent 10 integers, then will the lesser divisions stand for integers; and if the great divisions be supposed each 100, the subdivisions will be each 10.

USE OF GUNTER'S LINE.

1. *To find the product of two numbers.* From 1 extend the compasses to the multiplier; and the same extent, applied the same way from the multiplicand, will reach to the product. Thus if the product of 4 and 8 be required, extend the compasses from 1 to 4 and that extent laid from 8 the same way, will reach to 32, their product.

2. *To divide one number by another.* The extent from the divisor to unity will reach from the dividend to the quotient: thus to divide 36 by 4, extend the compasses from 4 to 1, and the same extent will reach from 36 to 9, the quotient sought.

3. *To three given numbers, to find a fourth proportional.* Suppose the numbers 6, 8, 9; extend the compasses from 6 to 8, and this extent, laid from 9 the same way, will reach to 12, the fourth proportional required.

4. *To find a mean proportional between any two given numbers.* Suppose 8 and 32: extend the compasses from 8 in the left-hand part of the line, to 32 in the right; then bisecting this distance, its half will reach from 8 forward, or from 32 backward, to 16, the mean proportional sought.

5. *To extract the square root of any number.* Suppose 25: bisect the distance between 1 on the scale and the point representing 25; then the half of this distance, set off from 1, will give the point representing the root 5. In the same manner the cube root, or that of any higher power, may be found by dividing the distance on the line, between 1 and the given number, into as many equal parts as the index of the power expresses; then one of those parts, set from 1, will find the point representing the root required.

GUNTER'S QUADRANT, one made of wood, brass, &c. containing a kind of stereographic projection of the sphere, on the plane of the equinoctial; the eye being supposed placed in one of the poles.

Besides the use of this quadrant in finding heights and distances, it serves also to find the hour of the day, the sun's azimuth, and other problems of the globe.

GUNTER'S SCALE, usually called by seamen *the Gunter*, is a large plane scale, having various lines upon it, of great use in working the cases or questions in navigation.

This scale is usually two feet long, and about an inch and a half broad, with various lines upon it, both natural and logarithmic, relating to trigonometry, navigation, &c.

On one side are the natural lines, and on the other the artificial or logarithmic ones. The former side is first divided into inches and tenths, and numbered from 1 to 24 inches, running the whole length near one edge. One-half the length of this side consists of two plane diagonal scales, for taking off dimensions to three places of figures. On the other half or foot of this side are contained various lines relating to trigonometry, in the natural numbers, and marked thus, viz.

Rumb, the rumb or points of the compass;
Chord, the line of chords;
Sine, the line of sines;
Tang. the tangents;
S. T. the semitangents; and at the other end of this half are,
Leag. leagues, or equal parts;
Rumb. another line of rumbs;
M. L. miles of longitude;
Chor. another line of chords.

Also in the middle of this foot are *L.* and *P.* two other lines of equal parts. And all these lines on this side of the scale serve for drawing or laying down the figures to the cases in trigonometry and navigation.

On the other side of the scale are the following artificial or logarithmic lines, which serve for working or resolving those cases, viz.

S. R. the sine rumbs;
T. R. the tangent rumbs;
Numb. line of numbers;
Sine. sines;
V. S. the versed sines;
Tang. the tangents;
Meri. meridional parts;
E. P. equal parts.

GUN-WALE, or GUNNEL, is the uppermost wale of a ship, or that piece of timber which reaches on either side from the quarter-deck to the forecastle, being the uppermost bend which finishes the upper works of the hull, in that part in which are put the stanchions which support the waste-trees.

GUSSET, in heraldry, is formed by a line drawn from the dexter or sinister chief points, and falling down perpendicularly to the extreme base. The gusset is an abatement of honour, denoting an effeminate person.

GUSTAVIA, a genus of the polyandria order, in the

monadelphia class of plants. There is no calyx; the petals very numerous; the berry multilocular; the seeds appendaged. There is one species, a tree of Surinam.

GUTTÆ. See ARCHITECTURE.

GUTTA-SERENA, a disease in which the patient, without any apparent fault in the eye, is entirely deprived of sight. See SURGERY.

GUTTY, in heraldry, a term used when any thing is charged or sprinkled with drops. In blazoning, the colour of the drops is to be named, as gutty of sable, of gules, &c.

GUY, in a ship, is any rope used for keeping off things from bearing or falling against the ship's sides when they are hoisting in. That rope which at one end is made fast to the foremast, and seized to a single block at the pendant of the garnet, is called the guy of the garnet.

GUZES, in heraldry, roundles of a sanguine or murry colour. These, from their bloody hue, are by some supposed to represent wounds.

GYMNANTHES, a genus of the class and order monœcia monadelphia. The male has an ament naked; perianthium and corolla none; stamina pedicles, three-parted or three-forked, anther bearing. The female has an ament or germ pedicelled; corolla none; style trifid: capsule tricoccous, three-celled. There are two species, shrubs of the West Indies.

GYMNETRUS, a genus of fishes, of the order of thoracici. The generic character is, body extremely long, compressed; teeth numerous, subulate; gill membrane, four or five-rayed; anal fin wanting. The most remarkable species are:

1. Gymnetrus Ascanii, or ascanian gymnetrus. This extraordinary fish is a native of the northern seas, and seems to have been first described by professor Ascanius, in his work entitled Icones rerum Natularium, &c. The length of the specimen was ten feet, and the diameter, which was equal throughout the whole length, about six inches: the head short, the mouth small, and the eyes rather large: on the upper part of the head, before the commencement of the dorsal fin, were situated 7 or 8 upright naked rays or processes, of moderate length: the dorsal fin, which was rather shallow, commenced at a small distance beyond these, and running along the whole length of the back, formed by its continuation the tail-fin: the ventral fins, if they can be said to deserve the name, consisted of a pair of extremely long single rays or processes terminated by a small ovate expanded tip or finny extremity: the gill-covers appeared to consist of five or six radiated laminæ: the colour of the whole body was bright silver, with a blueish cast diffused over the upper part of the back: the lateral line was strongly marked, and ran from the gill-covers to the tail, and the sides of the body were marked by several longitudinal double rows of slightly extant, very small dusky specks; the forehead was white; the fins pale brown.

This fish is said to be generally seen either preceding or accompanying the shoals of herrings in the northern seas, for which reason it is popularly known by the title of king of the herrings.

2. Blochian gymnetrus. This which is a native of the Indian seas, and which appears also to be occasionally seen in those of Europe, is described by Dr. Bloch from a drawing communicated by J. Hawkins, Esq. In its general appearance it is much allied to the preceding kind, but appears to be furnished with two pair of ventral processes, which are of considerable length, and terminate in large, dilated, finny extremities, of an oval form: the back-fin is continued as far as the tail. The colour of this species is silvery, with a blueish cast on the upper parts, and several transverse, alternate, brownish shades continued along the body, accompanied by large, distant, round spots, of a similar colour: the fins and processes deep crimson: the pectoral fins pretty large in proportion.

It appears from a print published in the year 1798, that a specimen of this fish was thrown on the coast of Cornwall in the month of February in the same year. Its length was eight feet six inches, its breadth in the widest part ten inches and a half, and its thickness only two inches and three quarters; the tail in this specimen was wanting; the colours the same as the specimen figure by Dr. Bloch.

GYMNOSOPHISTS, a sect of philosophers who clothed themselves no farther than modesty required. There were some of these sages in Africa; but the most celebrated clan of them was in India. The African gymnososophists dwelt upon a mountain in Ethiopia, near the Nile, without the accommodation of either house or cell. They did not form themselves into societies like those of India, but each had his private retirement, where he studied and performed his devotions by himself. If any person had killed another by chance, he applied to these sages for absolution, and submitted to whatever penances they enjoined. They observed an extraordinary frugality, and lived only upon the fruits of the earth. Lucan ascribes to these gymnosophists several new discoveries in astronomy.

The Indian gymnosophists dwelt in the woods, where they lived upon the wild products of the earth, and never drank wine, nor married. Some of them practised physic, and travelled from one place to another: these were particularly famous for their remedies against barrenness. Some of them, likewise, pretended to practise magic, and to foretell future events.

GYMNOSPERMIA, in botany, from γυμνος, naked, and σπερμα, seed; the first order in Linnæus's class of didynamia. It comprehends those plants of that class which have naked seeds. The seeds are constantly four in number, except in one genus, viz. phryma, which is monospermous.

GYMNOTUS, *gymnote*, a genus of fishes belonging to the apodes. The generic character is, head with lateral opercula; tentacula two on the upper lip; eyes covered by the common skin; gill-membrane five-rayed; body compressed, without dorsal fin (in most species), but carinated by a fin beneath. The most remarkable species, are:

1. The gymnotus electricus, a native of the warmer regions of Africa and America, where it inhabits the larger rivers, and is particularly found in those of Surinam. In Africa it is said chiefly to occur in the branches of the river Senegal. It is a fish of a disagreeable appearance; bearing a general resemblance to a large eel, though somewhat thicker in proportion, and of a much darker colour, being commonly of an uniform blackish-brown. It is usually seen of the length of three or four feet, but is said to arrive at a far larger size, specimens occasionally oc-

curring of 6, 7, or even ten feet in length. It was first made known to the philosophers of Europe about the year 1671, when its wonderful properties were announced to the French academy by Mons. Richer, one of the gentlemen sent out by the academy to conduct some mathematical observations in Cayenne. This account however seems to have been received with a degree of cautious scepticism by the major part of European naturalists; and it was not till towards the middle of the last century that a full and general conviction appears to have taken place; the observations of Mons. Condamine, Mr. Ingram, Mr. Gravesend, and others, then conspiring to prove that the power of this animal consists in a species of real electricity, being conducted by similar conducting substances, and intercepted by others of an opposite nature. Thus, on touching the fish with the fingers, the same sensation is perceived as on touching a charged phial; being sometimes felt as far as the elbows; and if touched by both hands, an electric shock is conveyed through the breast in the usual manner. Fermin, in particular, who, during his residence in Surinam, had frequent opportunities of examining the animal, demonstrated by experiment that 14 slaves, holding each other by the hands, received the shock at the same instant; the first touching the fish with a stick, and the last dipping his hand into the water in which it was kept. The experiments of Dr. Bancroft were equally satisfactory (see ELECTRICITY). It is by this extraordinary faculty that the gymnotus supports its existence: the smaller fishes and other animals which happened to approach it, being instantly stupified, and thus falling an easy prey to the electrical tyrant. So powerful is the shock which this fish, in its native waters, is capable of exerting, that it is said to deprive almost entirely of sense and motion those who are exposed to its approach, and is therefore much dreaded by those who bathe in the rivers which it inhabits. See Pl. LXVII. Nat. Hist. fig. 218.

It has been affirmed that the gymnotus electricus, even for some time after its death, cannot be touched without feeling its electric shock. This is by no means incredible, when we consider the effect of the galvanic pile, so well known to modern philosophers.

2. Gymnotus carapo. The head of the carapo is of a compressed form, and the upper jaw projects beyond the lower: the tongue is short, thick, broad, and furnished like the jaws with a great many small sharp-pointed teeth: the eyes are very small, and the front of the head is marked, as in the preceding species, by a number of small round pores: the body gradually decreases towards the tail, which is extremely slender, and terminates in a point. The colour of the whole animal is brown, marked by a few irregular spots or patches of a deeper cast: the scales are small, and the lateral line straight. This fish is a native of the American seas, and is said to be most frequent on the coast of Surinam. It is supposed to live chiefly on small fishes, sea insects, &c. Whether it possesses any electric power, like the former species, may be doubted; yet the structure of the lower part of the body seems to imply somewhat of a similar contrivance of nature. The usual length of the carapo is from 1 to 2 feet; but it is sometimes found of the length of three feet, and of the weight of more than ten pounds. It is considered as an esculent fish by the South Americans.

3. Gymnotus rostratus, or rostrated gymnote. In its general aspect this species is much allied to the carapo, but is readily distinguished by the peculiar form of the head, which terminates in a narrow, slightly compressed, tubular snout, the jaws appearing in a manner connate: the colour of the body is pale reddish-brown, variegated with differently sized spots of a darker colour, and which are much smaller, as well as more numerous, on the fin than on the other parts: the pectoral fins are round, and rather small for the size of the animal: the eyes are very small: the scales, if any, are so small as to be not distinctly visible on a general view. This species is a native of Surinam, and seems to have been first described and figured by Seba.

4. Gymnotus acus, or needle gymnote. This species is described by Brunnich, in his history of the fish of Marseilles. It is whitish, with reddish and brown spots, which cause a kind of clouded variegation on the back, while a blueish tinge prevails towards the under parts: on the back is a kind of projection, which may be rather considered as a rudiment of a fin than a perfect one: the whole animal is of a long, compressed, and attenuated form, and the mouth is destitute of tentacula. This is the only European species of gymnote yet discovered, and is a native of the Mediterranean sea. Biside these there are 11 other species.

GYNANDRIA, from γυνή, a woman, and ἀνήρ, a man, the name of the 20th class in Linnæus's sexual system, consisting of plants with hermaphrodite flowers, in which the stamina are placed upon the style, or, to speak more properly, upon a pillar-shaped receptacle resembling a style, which rises in the middle of the flower, and bears both the stamina and pointal; that is, both the supposed organs of generation, (see BOTANY). The flowers of this class, says Linnæus, have a monstrous appearance; arising, as he imagines, from the singular and unusual situation of the parts of fructification.

GYNOPOGON, a genus of the pentandria monogynia class and order. The calyx is half five-cleft; corolla five-parted; stigma globular, two lobed; berry pedicelled, sub-globular; seed cartilaginous. There are three species, herbs of the South Seas, of no note.

GYPSUM. See LIME, *sulphat of.*

What formerly was called gypsum, or selenite, is now known to be a sulphat of lime. It is also distinguished by the name of plaister stone, &c.

GYRINUS, or glimmerchaffer, a genus of insects of the coleoptera order. The generic character is, antennæ clavated, stiff, shorter than the head: eyes (apparently) four, two above and two below.

The genus gyrinus is furnished with extremely short, stiff antennæ, appearing to consist of an undivided piece or joint; but, if accurately inspected by means of a magnifier, they will be found to be composed of very numerous close set joints: the eyes are so placed as to appear double on each side the head, viz. one above, and the other below the base of the antennæ.

The most remarkable European species is the gyrinus natator, a small insect, about a quarter of an inch in length, of an oval shape, with somewhat sharpened extremities, and of a black or grey-black colour, with so lucid a surface as to shine like a piece of looking-glass in the full sunshine. It is an inhabitant of the waters, and

is chiefly found in rivulets, being generally seen in great multitudes, and in very brisk motion. It is difficult to catch, diving with astonishing celerity when disturbed; the hinder legs being very broad, finely webbed with minute hairs, and most curiously formed for exercising the office of fins or oars. The larva is of a highly singular aspect, having a very lengthened body, furnished, exclusive of six legs on the foreparts, with a great many lateral appendages or processes down the body; those towards the extremity considerably exceeding the rest. In its motions it is extremely agile, swimming in a kind of serpentine manner, and preying on the smaller and weaker water-insects, minute worms, &c.; the head is armed with a pair of forceps, pierced on each side the tip with a small foramen, through which it sucks the juices of the animals on which it preys; the colour of this larva is a very pale or whitish brown, with a high degree of transparency, which renders it a very curious object for the microscope: its length, when full-grown, is about three quarters of an inch. When the time of its changes arrives, it forms for itself a small oval cell or case on a leaf of sedge, or other convenient water-plant, and after casting its skin, becomes a chrysalis: this change usually takes place in the month of August, and the complete insect emerges in that of September.

When these animals are congregated together in great multitudes on the surface of the water, which frequently happens in hot weather, they have been observed to diffuse a strong or disagreeable smell to a considerable distance. Like other water-beetles they fly only by night. They deposit their eggs, which are very small, white, and of a somewhat cylindric form, on the stems of water-plants; they hatch in the space of about eight days, and immediately begin to swim about with much briskness in quest of prey. There are only 2 species.

GYRFALCON. See Falco.

GYPSIES. See Egyptians.

GYPSOPHILA, a genus of the digynia order, in the decandria class of plants, and in the natural method ranking under the 22d order, caryophillei. The calyx is monophyllous, campanulated, and angulated; the petals are five in number, ovate, and sessile; the capsule globose and unilocular. There are 12 species, herbs of Europe.

H.

H, the eighth letter in our alphabet; used as a numeral, denotes 200; and with a dash over it, $\overline{H}$, 200,000.

As an abbreviation, H was used by the ancients to denote *homo*, *hæres*, *hora*, &c. Thus H. B. stood for hæres bonorum; and H. S. corruptly for L. L. S. a sesterce; and H. A. for Hadrianus.

HABDALA, a ceremony of the Jews, observed on the sabbath in the evening; intended to signify that the sabbath is over, and if from that moment divided from the day of labour which follows. For this reason the ceremony is called habdala, which signifies distinction.

HABEAS CORPUS. This writ formed part of the ancient common law, but was much more restrained in its operation and effects; for the judges arrogated to themselves the power of granting or denying it; and the gaolers did not pay a proper attention to it, often putting the sufferer to the expense of an alias and pluries habeas corpus before they obeyed. These inconveniences produced the famous statute 31 Car. II. c. 2.

This great bulwark of English liberty, which may fairly be put upon a level with the celebrated Magna Charta, was occasioned by the unjust oppression of an insignificant individual in the reign of Charles the Second. The statute enacts,

1st. That the lord chancellor, or any of the judges in vacation, on complaint or written request of any person committed for any crime (except felony, or treason, or as accessary, or suspected of being accessary before the fact, to any petty treason, or felony, or charged in execution by legal process), upon seeing a copy of the warrant, or affidavit that copy is denied, shall award a habeas corpus for such prisoner, returnable immediately before himself, or any other of the judges (unless the party has suffered two terms to elapse before applying to the court for his liberation), and shall discharge the party, if bailable, on his giving proper security to appear.

2dly. That the writ shall be indorsed, as granted in pursuance to this act, and signed by the person awarding it.

3dly. That the writ shall be returned, and the prisoner brought up in a limited time, according to the distance, never exceeding 20 days.

4thly. That officers and keepers not making due returns, or not delivering to the party or his agent, within six hours after demand, a copy of the warrant of commitment, or shifting the custody of a prisoner without proper authority (as mentioned in the act), shall forfeit 100*l.* for the first offence, and 200*l.* for the second, to the sufferer, and be disabled from holding such office.

5thly. That any one detaining a person once delivered by habeas corpus for the same offence, shall forfeit 500*l.*

6thly. That every person committed for treason or felony shall, if he desires it, the first week of the next term, or the first day of the next session of oyer and terminer, be indicted in that term or session, or else admitted to bail, unless the witnesses for the crown cannot be produced at that time, and if acquitted, or not indicted, and tried in the second term or session, shall be discharged; but no person after the commencement of assizes for the county where he is detained, shall be removed by habeas corpus till they are ended.

7thly. That a prisoner can obtain his habeas corpus out of the chancery and exchequer, as well as out of the king's bench and common pleas; and if the chancellor and judges shall refuse the same on sight of the warrant or oath that it is denied, shall forfeit severally 500*l.* to the party grieved.

8thly. That this writ of habeas corpus shall run into

the counties palatine, and all other privileged places, and the islands of Guernsey and Jersey.

9thly. That no inhabitants of England (unless at their desire, or having committed some capital offence in the place to which they are sent), shall be sent prisoners to Ireland, Scotland, Guernsey, and Jersey, or any places beyond the seas, within or without his majesty's dominions, on pain that the person committing, and his advisers and abettors, shall forfeit to the injured party a sum not less than 500*l.* to be recovered with treble costs, shall be disabled from holding any office, shall incur the penalties of præmunire, and be incapable of the king's pardon.

The writs in use under this act are various. Many kinds are used for removing prisoners from one court to another. Such are the *habeas corpus ad respondendum,* when a man has cause of action against one who is confined by process of an inferior court, in order to remove the prisoner, and charge him with this new action in the court above. *Ad satisfaciendum* is when judgment has, in an action, been given against a prisoner, and the plaintiff brings him up to a superior court to charge him with process of execution. Also the writs *ad prosequendum, testificandum, deliberandum,* which issue when it is necessary to remove a prisoner, in order to prosecute, or bear testimony, or to be tried in the proper jurisdiction, wherein the fact was committed. And, lastly, he common writ *ad faciendum et recipiendum,* which issues out of any of the courts above, when a person is sued in some inferior jurisdiction, and desires to remove the action into the superior court, commanding the inferior judges to produce the body of the defendant, with the day and cause of his detainer, to do and receive what the king's court shall determine. This writ is grantable of common right, without moving the court, and supersedes all inferior proceedings. But to prevent the surreptitious discharge of prisoners, the statute 1 and 2 P. and M. c. 13, enacts, that no habeas corpus shall issue to remove any prisoner out of goal, unless signed by some judge of the court out of which it is awarded. And by a statute of the present reign it is enacted, that no cause under the value of 10*l.* shall be removed into a superior court, unless the defendant, on removing the same, gives security for payment of debt and costs.

But the writ which forms so great a part of the liberty of the subject in all manner of illegal confinement, is the *habeas corpus ad subjiciendum,* commanding the person detaining a prisoner to produce him, with the day and cause of his detension, to submit to whatever the judge or court awarding such writ shall determine. This is a high prerogative writ, and therefore, by the common law, issuing out of the court of king's bench, not only in term time, but vacation, by a fiat from any of the judges, and running into all the king's dominions. And a man has now the benefit of the common law writ, either in the king's bench or common pleas, as he chooses; and in both those courts it is necessary to apply for it by motion, as it does not issue of course, without showing some reason for the granting it. But if good grounds be shown that the party is imprisoned without just cause, it becomes a writ of common right, and must not be denied, even though a man is detained by the highest authority.

This celebrated act has been subject to temporary suspensions, by authority of parliament, in times of riot or rebellion; and the late minister subjected himself to considerable unpopularity by that measure during the last war.

HABENDUM, in a deed, is to determine what estate or interest is granted by the deed, the certainty thereof, for what time, and to what use. It sometimes qualifies the estate, so that the general implication thereof, which, by construction of law, passes in the premises, may by the habendum be controlled: in which case the habendum may lessen or enlarge the estate, but not totally contradict or be repugnant to it. As if a grant is to one and the heirs of his body, to leave to him and his heirs for ever, here he has an estate tail by the grant, and by the habendum he has a fee simple expectant thereon. But if it had been in the premises to him and his heirs, to have for life, the habendum would be utterly void; for an estate of inheritance is vested in him before the habendum comes, and shall not afterwards be taken away, or divested by it. 2 Black. 298.

The habendum cannot pass any thing that is not expressly mentioned, or contained by implication in the premises of the deed; because the premises being part of the deed by which the thing is granted, and consequently that makes the gift; it follows that the habendum, which only limits the certainty and extent of the estate in the thing given, cannot increase or multiply the gift, because it would be absurd to say that the grantee shall hold a thing which was never given him. 2 Roll. Abr. 65. See DEED.

HABERDASHER, in commerce, a seller of hats, or of small wares.

The master and wardens of the company of haberdashers in London, calling to their assistance one of the company of cappers, and another of the hat-makers, and mayors, &c. of towns, may search the wares of all hatters that work hats with foreign wool, and have not been apprentices to the trade, or who dye them with any thing but copperas and galls, or woad and madder; in which case they are liable to penalties, by stat. 8 Eliz. c. 7, and 5 Geo. II. c. 22.

HABERE FACIAS SEISINAM, a writ of execution directed to the sheriff, commanding him to give to the plaintiff possession of a freehold: if it is a chattel interest, and not a freehold, then the writ is entitled habere facias possessionem. 3 Black. 412.

In the execution of these writs, the sheriff, if needful, may take with him the power of the county, and may justify breaking open doors, if the possession is not quietly delivered; but if it is peaceably delivered up, the yielding of a twig, a turf, or the ring of a door, in the name of seisin, is sufficient. Id.

HABERE FACIAS VISUM, a writ that lies in divers cases in real actions, as in dower, formedon, &c. where view is required to be taken of the lands or tenements in question.

HABERGEON, a small coat of mail, or only sleeves and gorget of mail, formed of little iron rings or meshes linked into each other.

HADDOCK. See GADUS.

HÆMANTHUS, the *blood flower,* a genus of the monogynia order, in the hexandria class of plants, and in the natural method ranking under the ninth order, spathaceæ. The involucrum is hexaphyllous and multiflo-

rous; the corolla sexpartite, superior; the berry trilocular. There are eight species, of which the principal are:

1. The coccineus, with plain tongue-shaped leaves, rises about a foot high, with a stalk supporting a cluster of bright-red tubulous flowers. It has a large bulbous root, from which in the autumn come out two broad flat leaves of a fleshy consistence, shaped like a tongue, which turn backward on each side, and spread on the ground, so that they have a strange appearance all the winter. In the spring these decay; so that from May to the beginning of August they are destitute of leaves. The flowers are produced in the autumn just before the leaves come out.

2. The carinatus, with keel-shaped leaves, has a taller stalk and paler flowers than the former; its leaves are not flat, but hollowed like the keel of a boat.

3. The puniceus, with large spear-shaped waved leaves, grows about a foot high, and has flowers of a yellowish-red colour. These are succeeded by berries, which are of a beautiful red colour when ripe. All these plants are natives of the Cape of Good Hope.

HÆMATITES, or *blood stone*, a hard mineral substance, red, black, or purple, but the powder of which is always red. It is found in masses sometimes spherical, semi spherical, pyramidal, or cellular, that is, like a honeycomb. It contains a large quantity of iron. Forty pounds of that metal have been extracted from a quintal of stone; but the iron is of such a bad quality, that this ore is not commonly smelted. The great hardness of hæmatites renders it fit for burnishing and polishing metals. The specific gravity from 47 to 50. See Plate LXVII. Nat. Hist. fig. 220.

HÆMATOPUS, the *sea-pye*, in ornithology, a genus belonging to the order of grallæ. The beak is compressed, with an equal wedge-shaped point; the nostrils are linear; and the feet have three toes without nails. There is but one species, viz. the ostralegus, or oyster-catcher, a native of Europe and America. See Plate LXVII. N. H. fig. 219. It feeds upon shell-fish near the sea-shore, particularly oysters and limpets. On observing an oyster which gapes wide enough for the insertion of its bill, it thrusts it in, and takes out the inhabitant: it will also force the limpets from their adhesion to the rocks with sufficient ease. Occasionally it feeds on marine insects and worms. With us these birds are often seen in considerable flocks in winter: in the summer they are met with only in pairs, though chiefly in the neighbourhood of the sea or salt rivers.

HÆMATOXYLUM, *logwood*, or *Campeachy wood*, a genus of the monogynia order, in the decandria class of plants, and in the natural method ranking under the 33d order, lomentaceæ. The calyx is quinquepartite; the petals five; the capsule lanceolated, unilocular, and bivalved; the valves navicular, or keeled like a boat. Of this genus there is only one species, viz. the campeachianum, which grows naturally in the bay of Campeachy at Honduras, and other parts of the Spanish West Indies, where it rises from 16 to 24 feet high. The stems are generally crooked, and very deformed, and seldom thicker than a man's thigh. The branches, which come out on each side, are crooked, irregular, and armed with strong thorns, and winged leaves, composed of three pair of obscure lobes indented at the top The flowers come in a racemus from the wings of the leaves, standing erect, and are of a pale-yellowish colour, with a purple empalement. They are succeeded by flat oblong pods, each containing two or three kidney-seeds.

Logwood is used in great quantities for dyeing purple, but especially black colours. All the colours, however, which can be prepared from it, are of a fading nature, and cannot by any art be made equally durable with those prepared from some other materials. Of all the colours prepared from logwood, the black is the most durable. Doctor Lewis recommends it as an ingredient in making ink. "In dyeing cloth (says he), vitriol and galls, in whatever proportions they are used, produce only browns of different shades: I have often been surprised that with these capital materials of the black dye I never oould obtain any true blackness in white cloth, and attributed the failure to some unheeded mismanagement in the process, till I found it to be a known fact among the dyers. Logwood is the material which adds blackness to the vitriol and gall brown; and this black dye, though not of the most durable kind, is the most common. On blue cloth a good black may be dyed by vitriol and galls alone; but even here an addition of logwood contributes not a little to improve the colour." Mr. Delaval, however, in his Essay on Colours, informs us, that with an infusion of galls and iron-filings, he not only made an exceeding black and durable ink, but also linen cloth of a very deep black.

HÆMOPTOSIS, in medicine, a spitting of blood. See MEDICINE.

HÆMORRHAGE, in medicine, a flux of blood from any part of the body. See MEDICINE.

HÆMORRHOIDS, or PILES. See MEDICINE.

HÆRUCA, in entomology, a genus of the order of vermes intestina. The body is round, the fore part two-necked, and surrounded with a single row of prickles. The H. muris is grey-white and wrinkled: it inhabits the intestines of the mouse, and is distinguished from the echinorhynchus, in wanting the retractile proboscis.

HAIL, in natural history, a meteor generally defined frozen rain, but differing from it in that the hailstones are not formed of single pieces of ice, but of many little spherules agglutinated together. Neither are these spherules all of the same consistence; some of them being hard and solid like perfect ice; others soft, and mostly like snow hardened by a severe frost. Sometimes the hailstone has a kind of core of this soft matter; but more frequently the core is solid and hard, while the outside is formed of a softer matter. Hailstones assume various figures, being sometimes round, at other times pyramidal, crenated, angular, thin, and flat, and sometimes stellated, with six radii like the small crystals of snow. See METEOROLOGY.

Natural historians furnish us with various accounts of surprising showers of hail, in which the hailstones were of extraordinary magnitude. Mezeray, speaking of the war of Louis XII. in Italy, in the year 1510, relates, that there was for some time a horrible darkness, thicker than that of night; after which the clouds broke into thunder and lightning, and there fell a shower of hailstones, or rather (as he calls them) pebble-stones, which destroyed all the fish, birds, and beasts, of the country. It was attended with a strong smell of sulphur; and the

stones were of a blueish colour, some of them weighing a hundred pounds. Hist. de France, tom. ii. p. 339.

At Lisle, in Flanders, in 1686, fell hail-stones of a very large size; some of which contained in the middle a dark-brown matter, which, thrown on the fire, gave a very great report. Phil. Trans. No. 203.

Dr. Halley and others also relate, that in Cheshire, Lancashire, &c. April 29, 1697, a thick black cloud coming from Carnarvonshire, disposed the vapours to congeal in such a manner, that for about the breadth of two miles, which was the limit of the cloud, in its progress, for the space of 60 miles, it did inconceivable damage; not only killing all sorts of fowls and other small animals, but splitting trees, knocking down horses and men, and even ploughing up the earth; so that the hailstones buried themselves under ground an inch or an inch and a half deep. The hailstones, many of which weighed five ounces, and some half a pound, and being five or six inches about, were of various figures; some round, others half-round; some smooth, others embossed and crenated: the icy substance of them was very transparent and hard, but there was a snowy kernel in the middle of them.

In Hertfordshire, May 4, the same year, after a severe storm of thunder and lightning, a shower of hail succeeded the former: some persons were killed by it, and their bodies were beaten all black and blue; vast oaks were split, and fields of rye cut down as with a scythe. The stones measured from 10 to 13 or 14 inches about. Their figures were various, some oval, others picked, and some flat. Philosoph. Trans. No. 229.

Methods have lately been proposed, in England and France, to draw off the lightning, and dissipate hailstorm. Monthly Magazine, July 1806.

HAIR. See Physiology.

Hair and feathers cover different parts of animals, and are obviously intended by nature to protect them from the cold. For this their softness and pliability, and the slowness with which they conduct heat, render them peculiarly proper.

1. Hair is usually distinguished into various kinds, according to its size and appearances. The strongest and stiffest of all is called bristle: of this kind is the hair on the back of hogs. When remarkably fine, soft, and pliable, it is called wool; and the finest of all is known by the name of down. But all these varieties resemble one another very closely in their composition.

Hair appears to be a kind of tube covered with a cuticle. Its surface is not smooth, but either covered with scales, or consisting of imbricated cones. Hence the roughness of its feel, and the disposition which it has to entangle itself, which has given origin to the process of felting and fulling. It is constantly increasing in length, being protruded from the roots, and seems at first to be soft or nearly gelatinous. From the experiments which have been made on hair by Achard and Hatchett, it follows that it contains gelatine, to which it owes its suppleness and toughness. This substance may be separated by boiling the hair in water. When thus treated it becomes much more brittle than before. Indeed if the process is continued long enough, the hair crumbles to pieces between the fingers. The portion insoluble in water possesses the properties of coagulated albumen.

Mr. Hatchett has concluded, from his experiments, that the hair which loses its curl in moist weather, and which is the softest and most flexible, is that which yields its gelatine most easily; whereas strong and elastic hair yields it with the greatest difficulty, and in the smallest proportion. This conclusion has been confirmed by a very considerable hair-merchant in London, who assured him that the first kind of hair was much more injured by boiling than the second.

The rapidity with which hair burns, and the fusion which it undergoes in that case, shows us, however, that hair does not altogether correspond with coajulated albumen in its nature, but approaches towards the oils. When distilled, 1152 parts of hair yielded Bertholett the following products:

90	carbonat of ammonia
179	water smelling of burnt hair
288	oil
271	gases
324	coal
1152.	

The oil was of a brown colour, solid unless exposed to a heat equal to 73°, very soluble in alcohol, burnt with great brilliancy, and with scintillations like hair. The charcoal was difficult to incinerate, and was attracted by the magnet; of course it contained iron. From the experiments of Fourcroy and Vauquelin, we learn that horsehair, when burnt, leaves a residuum of 0.12, which is mostly phosphat of lime.

The alkalies dissolve hair at a boiling-heat, and form with it an animal soap; but lime appears to have but little action on it. When muriatic acid is poured into the solution of hair in potass, a quantity of sulphureted hydrogen gas is disengaged, and a black substance, doubtless charcoal, precipitates. Hence it follows that it contains sulphur. Accordingly, if a bit of silver is put into the solution, it instantly assumes a black colour.

Sulphuric acid dissolves hair by the assistance of heat, some charcoal is deposited, and carbonic acid gas separates. Nitric acid tinges it yellow, and dissolves it when assisted by heat; while a fat matter separates, and oxalic acid is formed. Bertholett obtained from wool more than half its weight of oxalic acid. Muriatic acid dissolves it readily; but the solution does not become black, and has much the appearance of a solution of glue in the same acid. Oxymuriatic acid whitens hair, and destroys its strength. When the hair is plunged into the acid in the state of gas, it is very soon converted into a pulp.

2. Feathers seem to possess very nearly the same properties with hair. Mr. Hatchett has ascertained that the quill is composed chiefly of coagulated albumen. Though feathers were boiled for a long time in water, Mr. Hatchett could obtain no traces of gelatine.

Hair's breadth, a measure of length, being the 48th part of an inch.

HALCYON. See Alcedo.

HALE. See Haul.

HALESIA, a genus of the monogynia order, in the dodecandria class of plants; and in the natural method ranking under the 18th order, bicornes. The calyx is quadridentated, superior; the corolla quadrifid; the nut quadrangular and dispermous. There are two species, herbaceous plants of North America.

HALF-MOON, in fortification, an outwork composed of two faces, forming a saliant angle, whose gorge is in form of a crescent, or half-moon; whence the name. See FORTIFICATION.

HALF-SEAL, that used in the court of chancery for sealing commissions to delegates, upon any appeal, in ecclesiastical or marine causes.

HALIOTIS, the ear-shell, a genus of insects belonging to the order of vermes testacea. This is an animal of the snail kind, with an open shell resembling an ear. There are nineteen species, distinguished by the figure of their shells.

HALLERIA, a genus of the angiospermia order, in the didynamia class of plants; and in the natural method ranking under the 40th order, personatæ. The calyx is trifid; the corolla quadrifid; the filaments longer than the corolla; the berry inferior and bilocular (the fruit not yet fully described). There is one species, a shrub of the Cape.

HALO, in physiology, a meteor in the form of a luminous ring or circle, of various colours, appearing round the bodies of the sun, moon, or stars. See OPTICS.

HAMELLIA, a genus of the monogynia order, in the pentandria class of plants; and in the natural method ranking with those of which the order is doubtful. The corolla is quinquefid; the berry quinquelocular, inferior, polyspermous. There are four species, trees of the West Indies.

HAMMER, a well-known tool used by mechanics, consisting of an iron head, fixed crosswise upon a handle of wood.

There are several sorts of hammers used by blacksmiths; as, 1. The hand-hammer, which is of such weight that it may be wielded or governed with one hand at the anvil. 2. The up-hand sledge, used with both hands, and seldom lifted above the head. 3. The about-sledge, which is the largest hammer of all, and held by both hands at the farthest end of the handle, and being swung at arm's-length over the head, is made to fall upon the work with as heavy a blow as possible. There is also another hammer used by smiths, called a rivetting-hammer, which is the smallest of all, and is seldom used at the forge, unless upon small work.

HAMSOKEN, is used in Scotland for the crime of him that violently, and contrary to the king's peace, assaults a man in his own house, which is punishable equally with ravishing a woman.

HANAPER *office*, in the court of chancery, is that out of which issue all original writs that pass under the great seal, and all commissions of charitable uses, sewers, bankrupts, ideocy, lunacy, and such-like. These writs, relating to the business of the subject, and the returns to them, were originally kept in a hamper, in hanaperio; the other writs, relating to matters wherein the crown is immediately or mediately concerned, were preserved in a little sack or bag, in parva baga; and thence has arisen the distinction of the hanaper office and petty-bag office: both of which belong to the common law court in chancery. 3 Black. 48.

HANCES, in a ship, are falls or descents of the fife rails, which are placed from the stern down to the gangways.

HAND. See ANATOMY.

HAND-BARROW, a wheelbarrow which is of great use in fortification, for carrying earth from one place to another, and in a siege, for carrying bombs or cannon-balls along the trenches.

HAND-BREADTH, a measure of three inches.

HAND-CUFFS, an instrument formed of two circular pieces of iron, each fixed on a hinge at the ends of a very short iron bar, which being locked over the wrists of a malefactor, prevents his using his hands

HAND-GRENADES. See GRENADES.

HARBINGER, an officer of the king's household, having four yeomen under him, who ride a days journey before the court, when it travels, to provide lodgings.

HARDENING, the giving a greater degree of hardness to bodies than they had before. See the article HARDNESS.

There are several ways for hardening iron and steel, as by hammering them, quenching them, when hot, in cold water, case-hardening, &c. See IRON.

HARDNESS, in bodies, a property directly opposite to fluidity; by which they resist the impression of any other substance, sometimes in an extreme degree. As fluidity has been found to consist in the motion of the particles of a body upon one another in consequence of a certain action of the universal fluid or elementary fire among them; we must conclude that hardness consists in the absence of this action, or a deficiency of what is called latent heat. This is confirmed by observing that there is an intermediate state betwixt hardness and fluidity, in which bodies will yield to a certain force, though they still make a considerable resistance. This is principally observed in the metals, and is the foundation of their ductility. It appears, indeed, that this last property, as well as fluidity, is entirely dependant on a certain quantity of caloric absorbed, or otherwise acting within the substance itself; for all the metals are rendered hard by hammering, and soft by being put again into the fire and kept there for some time. The former operation renders them hot as well as hard; probably, as Dr. Black observes, because the particles of metal are thus forced nearer one another, and those of fire squeezed out from among them. By keeping them for some time in the fire, that element insinuates itself again among the particles, and arranges them in the same manner as before, so that the ductility returns. By a second hammering this property is again destroyed, returning on a repetition of the heating, or annealing as it is called; and so on, as often as we please.

Hardness appears to diminish the cohesion of bodies in some degree, though their fragility does not by any means keep pace with their hardness. Thus, glass is very hard and very brittle; but flint, though still harder than glass, is much less brittle. Among the metals, however, these two properties seem to be more connected, though even here the connection is by no means complete. Steel, the hardest of all the metals, is indeed the most brittle; but lead, the softest, is not the most ductile. Neither is hardness connected with the specific gravity of bodies; for a diamond, the hardest substance in nature, is little more than half the weight of the lightest metal. As little is it connected with the coldness, electrical properties, or any other quality with which we are acquainted: so that though the principle above laid down may be accepted as a general foundation for our inquiries, a great num-

ber of particulars remain yet to be discovered before we can offer any satisfactory explanation.

All bodies become harder by cold; but this is not the only means of their doing so, for some become hard by heat as well as cold.

Mr. Quist and others have constructed tables of the hardness of different substances. The method pursued in constructing these tables was by observing the order in which they were able to cut or make any impression upon one another. The following table, extracted from M. Magellen's edition of Cronstedt's Mineralogy was taken from Dr. Quist Bergman, and Mr. Kirvan. The first column shows the hardness, and the second the specific gravity.

	H.	S.G.
Diamond from Ormus	20	3,7
Pink diamond	19	3,4
Bluish diamond	19	3,3
Yellowish diamond	19	3,3
Cubic diamond	18	3,2
Ruby	17	4,2
Pale ruby from Brazil	16	3,5
Ruby spinell	13	3,4
Deep-blue sapphire	16	3,8
Ditto paler	17	3,8
Topaz	15	4,2
Whitish ditto	14	3,5
Bohemian ditto	11	2,8
Emerald	12	2,8
Garnet	12	4,4
Agate	12	2,6
Onyx	12	2,6
Sardonyx	12	2,6
Occid. amethyst	11	2,7
Crystal	11	2,6
Carnelian	11	2,7
Green jasper	11	2,7
Reddish-yellow ditto	9	2,6
Schoerl	10	3,6
Tourmaline	10	3,0
Quartz	10	2,7
Opal	10	2,6
Chrysolite	10	3,7
Zeolite	8	2,1
Fluor	7	3,5
Calcareous spar	6	2,7
Gypsum	5	2,3
Chalk	3	2,7

HARE. See LEPUS.

HARIOT. See HERIOT.

HARMATTAN. The harmattan is a very singular wind, which blows periodically from the interior parts of Africa towards the Atlantic Ocean. The season in which it prevails is during the months of December, January, and February; it comes on indiscriminately at any hour of the day, at any time of the tide, or at any period of the moon, and continues sometimes only a day or two, sometimes five or six days, and it has been known to last fifteen and sixteen days. There are generally three or four returns of it every season. It blows with a moderate force, but not quite so strong as the sea-breeze.

A fog or haze is one of the peculiarities which always accompany the harmattan. The English, French, and Portuguese forts at Whydah, are not quite a quarter of a mile asunder, yet are frequently quite invisible to each other; the sun, concealed the greatest part of the day, appears only about a few hours at noon, and then of a mild red, exciting no painful sensation on the eye. The particles which constitute this fog are deposited on the leaves of trees, on the skins of the negroes, &c. and make them appear whitish.

Extreme dryness makes another extraordinary property of this wind; no dew falls during its continuance; vegetables are withered, and the grass becomes dry like hay. The natives take this opportunity to clear the land, by setting fire to the trees and plants while in that dry and exhausted state. The dryness is so extreme, that the covers of books, even closely shut up in a trunk, are bent as if exposed to the fire. Household furniture is much damaged; the pannels of wainscots split, and fineered work flies to pieces. The joints of a well-laid floor of seasoned wood open sufficiently to admit the breadth of a finger between them; but becomes as close as before on the ceasing of the harmattan. The human body does not escape the parching effects of this wind; the eyes, nostrils, lips, and palate, are rendered dry and uneasy; the lips and nose become sore, and though the air is cool, there is a troublesome sensation of pricking heat on the skin. If the harmattan continues four or five days, the scarf-skin peels off, first from the hands and face, and afterwards from the rest of the body.

Though this wind is so fatal to vegetable life, and occasions these troublesome effects to the human species, it is nevertheless highly conducive to health; it stops the progress of epidemics, and relieves the patients labouring under fluxes and intermittent fevers. Infection is not easy at that time to be communicated, even by inoculation. It is also remarkable for the cure of ulcers and cutaneous diseases. Econ. of Nat. b. 5.

HARMONICA. This word, when originally appropriated by Dr. Franklin to that peculiar form or mode of musical glasses, which he himself, after a number of happy experiments, had constituted, was written Armonica. It is derived from the Greek word ἁρμονια. The radical word is αρειν, to suit or fit one thing to another. Relations or aptitudes of sound, in particular, were understood by it; and in this view, Dr. Franklin could not have selected a name more expressive of its nature and genius for the instrument which we are now to describe; as, perhaps, no musical tone can possibly be finer, nor consequently susceptible of juster concords, than those which it produces.

"Mr. Puckridge, a gentleman from Ireland, was," says Dr. Franklin, "the first who thought of playing tunes formed of these tones. He collected a number of glasses of different sizes; fixed them near each other on a table; and tuned them, by putting into them water, more or less as each note required. The tones were brought out by pressing his fingers round their brims. He was unfortunately burnt here, with his instrument, in a fire which consumed the house that he lived in. Mr. E. Deleval, a most ingenious member of the royal society, made one in imitation of it, with a better choice and form of glasses, which was the first I saw or heard. Being charmed with the sweetness of its tones, and the music

be produced from it, I wished to see the glasses disposed in a more convenient form, and brought together in a narrower compass, so as to admit of a greater number of tones, and all within reach of hand to a person sitting before the instrument; which I accomplished, after various intermediate trials, and less commodious forms, both of glasses and construction, in the following manner:

"The glasses are blown as nearly as possible in the form of hemispheres, having each an open neck or socket in the middle. The thickness of the glass near the brim is about the tenth of an inch, or hardly so much, but thicker as it comes nearer the neck; which in the largest glasses is about an inch deep, and an inch and a half wide within; these dimensions lessening as the glasses themselves diminish in size, except that the neck of the smallest ought to be shorter than half an inch. The largest glass is nine inches diameter, and the smallest three inches. Between these there are 23 different sizes, differing from each other a quarter of an inch in diameter. To make a single instrument there should be at least six glasses blown of each size; and out of this number one may probably pick 37 glasses (which are sufficient for three octaves with all the semitones) that will be each either the note one wants, or a little sharper than that note, and all fitting so well into each other as to taper pretty regularly from the highest to the smallest. It is true that there are not 37 sizes; but it often happens that two of the same size differ a note or half a note in tone, by reason of a difference in thickness, and these may be placed one in the other without sensibly hurting the regularity of the taper form.

"The glasses being chosen, and every one marked with a diamond the note you intend it for, they are to be tuned by diminishing the thickness of those that are too sharp. This is done by grinding them round from the neck towards the brim, the breadth of one or two inches as may be required; often trying the glass by a well-tuned harpsichord, comparing the note drawn from the glass by your finger with the note you want, as sounded by that string of the harpsichord. When you come near the matter, be careful to wipe the glass clean and dry before each trial, because the tone is something flatter when the glass is wet than it will be when dry; and grinding a very little between each trial, you will thereby tone to great exactness. The more care is necessary in this, because if you go below your required tone, there is no sharpening it again but by grinding somewhat off the brim, which will afterwards require polishing, and thus increase the trouble.

"The glasses being thus toned, you are to be provided with a case for them, and a spindle on which they are to be fixed. My case is about three feet long, eleven inches every way wide within at the biggest end, and five inches at the smallest end; for it tapers all the way, to adapt it better to the conical figure of the set of glasses. This case opens in the middle of its height, and the upper part turns up by hinges fixed behind. The spindle is of hard iron, lies horizontally from end to end of the box within, exactly in the middle, and is made to turn on brass gudgeons at each end. It is round, an inch diameter at the thickest end, and tapering to a quarter of an inch at the smallest. A square shank comes from its thickest end through the box, on which shank a wheel is fixed by a screw. This wheel serves as a fly to make the motion equable, when the spindle, with the glasses, is turned by the foot like a spinning-wheel. My wheel is of mahogany, 18 inches diameter, and pretty thick, so as to conceal near its circumference about 25lb. of lead. An ivory pin is fixed in the face of this wheel, about four inches from the axis. Over the neck of this pin is put the loop of the string that comes up from the moveable step to give it motion. The case stands on a neat frame with four legs.

"To fix the glasses on the spindle, a cork is first to be fitted in each neck pretty tight, and projecting a little without the neck, that the neck of one may not touch the inside of another when put together, for that would make a jarring. These corks are to be perforated with holes of different diameters, so as to suit that part of the spindle on which they are to be fixed. When a glass is put on, by holding it stiffly between both hands, while another turns the spindle, it may be gradually brought to its place. But care must be taken that the hole be not too small, lest in forcing it up, the neck should split; nor too large, lest the glass, not being firmly fixed, should turn or move on the spindle, so as to touch or jar against its neighbouring glass. The glasses thus are placed one in another; the largest on the biggest end of the spindle, which is to the left hand: the neck of this glass is towards the wheel; and the next goes into it in the same position, only about an inch of its brim appearing beyond the brim of the first; thus proceeding, every glass when fixed shows about an inch of its brim (or three quarters of an inch, or half an inch, as they grow smaller) beyond the brim of the glass that contains it; and it is from these exposed parts of each glass that the tone is drawn, by laying a finger on one of them as the spindle and glasses turn round.

"My largest glass is G a little below the reach of a common voice, and my highest G, including three complete octaves. To distinguish the glasses more readily by the eye, I have painted the apparent parts of the glasses within side, every semistone white, and the other notes of the octave with the seven prismatic colours; viz. C, red; D, orange; E, yellow; F, green; G, blue; A, indigo; B, purple; and C, red again; so that the glasses of the same colour (the white excepted) are always octaves to each other.

"This instrument is played upon by sitting before the middle of the set of glasses, as before the keys of a harpsichord, turning them with the foot, and wetting them now and then with a sponge and clean water. The fingers should be first a little soaked in water, and quite free from all greasiness; a little fine chalk upon them is sometimes useful, to make them catch the glasses and bring out the tone more readily. Both hands are used, by which means different parts are played together. Observe, that the tones are best drawn out when the glasses turn *from* the ends of the fingers, not when they turn *to* them.

"The advantages of this instrument are, that its tones are incomparably sweet beyond those of any other; that they may be swelled and softened at pleasure by stronger or weaker pressures of the finger, and continued to any length; and that the instrument being once well tuned, never again wants tuning."

"Analogous to these sounds," says a writer in the Annual Register, "are those produced by bells: in those last, besides the tones produced by their elliptical vibrations, there are a set of tones which may be brought by gently rubbing their edges, and in which the whole instrument does not appear to vibrate in all its parts as before.

"Take, for instance, a bell finely polished at the edges; or, what will perhaps be more convenient, a drinking-glass: let the edges be as free from any thing oily as possible; then, by moistening the finger in water (I have found alum-water to be best), and rubbing it circularly round the edge of the glass, you will at length bring out the tone referred to.

"This note is possessed of infinite sweetness; it has all the excellences of the tone of a bell, without its defects. It is loud, has a sufficient body, is capable of being swelled and continued at pleasure; and besides, has naturally that vibratory softening which musicians endeavour to imitate by mixing with the note to be played a quarter-tone from below.

"To vary these tones, nothing more is required than to procure several bells or glasses of different tones, tuned as nearly as possible, which may be done by thinning the edges of either: or, for immediate satisfaction, the glasses may be tuned by pouring in water; the more water is poured in, the graver the tone will be.

"Let us suppose then a double octave of those glasses, thus tuned, to be procured. Any common tune may be executed by the fingers rubbing upon each glass successively; and this I have frequently done without the least difficulty, only choosing those tunes which are slow and easy. Here then are numbers of delicate tones, with which musicians have been till very lately unacquainted; and the only defect is, that they cannot be made to follow each other with that celerity and ease which is requisite for melody. In order to remedy this, I took a large drinking-glass, and by means of a wheel and gut, as in the electrical machine, made it to turn upon its axis with a moderately quick but equable motion; then moistening the finger as before, nothing more was required than merely to touch the glass at the edge, without any other motion, in order to bring out the tone.

"Instead of one glass only turning in this manner, if the whole number of glasses were so fixed as to keep continually turning by means of a wheel, it follows, that upon every touch of the finger a note would be expressed; and thus, by touching several glasses at once, a harmony of notes might be produced, as in a harpsichord.

"As I write rather to excite than satisfy the curious, I shall not pretend to direct the various ways this number of glasses may be contrived to turn; it may be sufficient to say, that if the glasses are placed in the segment of a circle, and then a strap, as in a cutler's wheel, is supposed to go round them all, the whole number will by this means be made to turn by a wheel.

"Instead of the finger, I have applied moistened leather to the edge of the glass, in order to bring out the tone: but, for want of a proper elasticity, this did not succeed. I tried cork, and this answered every purpose of the finger; but made the tone much louder than the finger could do. Instead, therefore, of the finger, if a number of corks were so contrived as to fall with a proper degree of pressure on the edge of the glass, by means of keys like the jacks of an organ, it is evident, that in such a case a new and tolerably perfect instrument would be produced; not so loud indeed as some, but infinitely more melodious than any."

HARMONICAL Arithmetic, that part of arithmetic which considers musical intervals, expressed by numbers, in order to our finding their mutual relations, compositions, and resolutions.

Harmonical Proportion. See Proportion.

Harmonical Series, a series of many numbers in continual harmonical proportion. Thus if there are four or more numbers, of which every three immediate terms are harmonical, the whole will make an harmonical series: such is 30: 20: 15: 12: 10. Or, if every four terms immediately next each other are harmonical, it is also a continual harmonical series, but of another species, as 3, 4, 6, 9, 18, 36, &c.

HARMONY, in music (from the Greek), the agreement or consonance of two or more united sounds. Harmony is either natural or artificial. Natural harmony, properly so called, consist of the harmonic triad, or common chord. Artificial harmony is a mixture of concords and discords, bearing relation to the harmonic triad of the fundamental note. The word harmony being originally a proper name, it is not easy to determine the exact sense in which it was used by the Greeks; but from the treatises they have left us on the subject, we have great reason to conclude that they limited its signification to that agreeable succession of sounds which we call air, or melody. The moderns, however, do not dignify a mere succession of single sounds with the appellation of harmony: for the formation of harmony they require an union of melodies, a succession of combined sounds composed of consonant intervals, and moving according to the stated laws of modulation. But as the laws of harmony were not established into a code but by very slow degrees, its principles for a long time consisted of no other than almost arbitrary rules, founded, indeed, on the approbation of the ear, but unsanctioned by that science which accounts for effects rationally, and deduces its conclusions from minute, profound, and satisfactory investigation. At length, however, writers arose, to whose patience, talents, and learning, the present age is indebted for a complete system of harmony and modulation, and to whose labours we only have to resort, to be informed on every point requisite both to its theory and practice.

Harmony, Figured. Figured harmony is that in which, for the purpose of melody, one or more of the parts of a composition move during the continuance of a chord, through certain notes which do not form any of the constituent parts of that chord. These intermediate notes not being reckoned in the harmony, considerable judgment and skill are necessary so to dispose them that while the ear is gratified with their succession, it may not be offended at their dissonance with respect to the harmonic notes. See Sounds.

HARP, a stringed instrument, consisting of a triangular frame, and the chords of which are distended in parallel directions from the upper part to one of its sides. Its scale extends through the common compass, and the strings are tuned by semitonic intervals. It stands erect,

and when used, is placed at the feet of the performer, who produces its tones by the action of the thumb and fingers of both hands on the strings. That the harp is among the most ancient of musical instruments, the frequent mention of it in scripture, and the splendid account transmitted to us of the Theban harp, both as to the beauty of its decorations and extent of scale, are sufficient evidences. The Irish and Welsh practised the harp long before the gammut of Guido was invented, and it is, indeed, their national instrument. In England also it was early introduced to general use, and the most ancient poems were sung to it on Sundays and all public festivals.

HARPING-IRON, or Harpoon, a large spear or javelin, made of forged iron, and five or six feet long; it is fastened to a line, and used in the whale-fishery.

HARPINGS, in a ship, properly denote her breadth at the bow. Some also give the same name to the ends of the bends that are fastened into the stern.

HARPOON-Gun, a sort of fire-arm for discharging harpoons at whales, and thereby killing them more expeditiously than when harpoons are thrown by the hand. See Transactions of the Society for the Encouragement of Arts, &c. 1786, 1789, &c.

HARPSICHORD, a stringed instrument, consisting of a case formed of mahogany or walnut-tree wood, and containing the belly or sounding-board, over which the wires are distended, supported by bridges. In the front the keys are disposed, the long ones of which are the naturals, and the short ones the sharps and flats. These keys being pressed by the fingers, their inclosed extremities raise little upright oblong slips of wood called jacks, furnished with crow-quill plectrums, which strike the wires. The great advantage of the harpsichord beyond most other stringed instruments, consists in its capacity of sounding many notes at once, and forming those combinations, and performing those evolutions of harmony, which a single instrument cannot command. This instrument, called by the Italians clave cymbala, by the French clavecin, and in Latin grave cymbalum, is an improvement upon the clarichord, which was borrowed from the harp, and has for more than a century been in the highest esteem, and in the most general use, both public and private, throughout Europe; but since the invention of that fine instrument the grand piano-forte, its practice has considerably declined.

HARQUEBUSS, a piece of fire-arms, of the length of a musquet, usually cocked with a wheel. It carried a ball that weighed one ounce seven eighths.

HARRIER. See Canis.

HARROW. See Husbandry.

HART. See Cervus.

HARTOGIA, a genus of the pentandria order, in the monœcia class of plants; and is the natural method ranking under the 48th order, aggregatæ. The male calyx is pentaphyllous, the petals five; the female calyx triphyllous, with five petals, and five barren and five castrated stamina. There are three capsules; and the seeds are arillated, or inclossed in a deciduous case. There is one species, a tree of the Cape.

HARTSHORN, in chemistry. See Ammonia.

Hart's Horns, in pharmacy, the whole horns of the common male deer, as separated from the head, without farther preparation. See Horns.

HASSELQUISTA, a genus of the class and order pentandria digynia. The cal. is radiated, in the disk male. Seeds in the circumference double, in the disk solitary. There are two species, herbs of Egypt.

HAT, a covering for the head, worn by the men in most parts of Europe and America. Those most in esteem are made of the pure hair of the castor or beaver; for they are also made of the hairs or wool of diver other animals, and that by much the same process.

Hats are made either of wool, or hair of various animals, particularly of the castor, hare, rabbit, camel, &c. The process is much the same in all; for which reason we shall content ourselves with instancing that of the beaver. The skin of this animal is covered with two kinds of hair; the one long, stiff, glossy, and rather thin-set; this is what renders the skin or fur of so much value: the other is short, thick, and soft, which alone is used in hats. To tear off one of these kinds of hair, and cut the other, the hatters, or rather the women employed for that purpose, make use of two knives, a large one like a shoemaker's knife for the long hair, and a smaller, not unlike a vine-knife, wherewith they shave or scrape off the shorter hair.

When the hair is off, they mix the stuff; to one-third of dry castor putting two-thirds of old coat, *i. e.* of hair which has been worn some time by the savages, and card the whole with cards, like those used in the woollen-manufactory, only finer; this done, they weigh it, and take more or less according to the size or thickness of the hat intended. The stuff is now laid on the hurdle, which is a square table, parallel to the horizon, having longitudinal chinks cut through it; on this hurdle, with an instrument called a bow, much like that of a violin, but larger, whose string is worked with a little bow-stick, and thus made to play on the furs, they fly and mix together, the dust and filth at the same time passing through the chinks. This they reckon one of the most difficult operations in the whole, on account of the justness required in the hand to make the stuff fall precisely together, and that it may be every where of the same thickness. In lieu of a bow, some hatters make use of a sieve or searce of hair, through which they pass the stuff.

After this manner they form gores, or two capades, of an oval form, ending in an acute angle at top; and with what stuff remains, they supply and strengthen them in places where they happen to be slenderer than ordinary; though it is to be remembered, that they designedly make them thicker in the brim, near the crown, than toward the circumference, or in the crown itself.

The capades thus furnished, they go on to harden them into closer and more consistent flakes by pressing down a hardening skin or leather thereon; this done, they are carried to the bason, which is a sort of bench with an iron plate fitted in it, and a little fire underneath; upon which laying one of the hardened capades, sprinkled over with water, and a sort of mould being applied, the heat of the fire, with the water and pressing, embody the matter into a slight hairy sort of stuff or felt; after which, turning up the edges all round the mould, they lay it by, and thus proceed to the other: this finished, the next two are joined together, so as to meet in an angle at the top, and only form one conical cap, after the manner of a manican hippocratis, or jelly-bag.

The hat thus basoned, they remove it to a large kind of receiver or trough, resembling a mill-hopper, going sloping or narrowing down from the edge or rim to the bottom, which is a copper kettle filled with water and grounds, kept hot for that purpose. On the descent or sloping side, called the plank, the basoned hat, being first dipped in the kettle, is laid; and here they proceed to work it, by rolling and unrolling it again and again, one part after another, first with the hand, and then with a little wooden roller, taking care to dip it from time to time, till at length, by thus fulling and thickening it four or five hours, it is reduced to the extent or dimensions of the hat intended.

The hat thus wrought, they proceed to give it the proper form, which is done by laying the conical cap on a wooden block, of the intended size of the crown of the hat, and then tying it round with a packthread: after which, with a piece of iron or copper bent for that purpose, and called a stamper, they gradually beat or drive it down all round, till it has reached the bottom of the block, and thus is the crown formed; what remains at bottom below the string being the brim.

The hat being set to dry, they proceed to singe it, by holding it over a flare of straw or the like; then it is pounced, or rubbed over with pumice, to take off the coarser knap; then rubbed over afresh with seal-skin to lay the knap a little finer; and lastly, carded with a fine card to raise the fine cotton, with which the hat is afterwards to appear.

Things thus far advanced, the hat is thus sent, upon its block, and tied about with a packthread as before, to be dyed. The dye being completed, the hat is returned to the hatter, who proceeds to dry it, by hanging it in the top or roof of the stove or oven, at the bottom of which is a charcoal fire; when dry, it is to be stiffened, which is done with melted glue or gum senegal, applied thereon by first smearing it, and beating it over with a brush, and then rubbing it with the hand. The next thing is to steam it on the steaming-bason, which is a little hearth or fire-place. When steamed sufficiently, and dried, they put it again on the block, and brush and iron it on a table or bench for the purpose, called the stall-board; this they perform with a sort of irons like those commonly used in ironing linen, and heated like them, which being rubbed over and over each part of the hat, with the assistance of the brush, smooths and gives it a gloss, which is the last operation; nothing now remains but to clip the edges even with scissars, and sew a lining to the crown. For dyeing of hats, see DYEING.

A patent was granted in January, 1782, to Mr. Robert Golding, of London, hat-dyer, for his method of dyeing, staining, and colouring, beaver hats green, or any other colour. The inventor directs the nap of the hat to be raised by means of a card, on the side intended to be dyed, and then boiled in alum argol. A thin paste should be made of flour, or clay, which is spread over every part that is not to be dyed, and then closed; or the hat may be previously pasted, and instead of being boiled, it should only be simmered in the same liquor. As soon as the paste is spread, plates of copper or other metal, shaped like a common funnel, are fixed over the paste, to prevent the dye from penetrating through. In this state the hat is immersed in the dye, till the colour is sufficiently fixed, when it is taken out, opened, and cleansed from the paste: but if any colouring particles have penetrated through the felt, they may be removed by rubbing them with a small quantity of spirit of salt, aquafortis, &c. The compounds employed in dyeing, are fustic, turmeric, ebony, saffron, alum, argol, indigo, and vitriol, with urine, or pearlash, at the option of the dyer; all which is used together, or separately, according to the colour required.

Mr. Dunnage, in 1794, obtained a patent for waterproof hats, in imitation of beaver. The articles he employs are similar to those commonly used for the making of hats, with which he mixes Bergam, Piedmont, or organzine silk. These are dressed and worked in a peculiar manner; though we understand that hats thus prepared become heavy and oppressive to the wearer, while they acquire an ugly colour. The same manufacturer procured another patent in November, 1798, for a method of ventilating the crowns of hats. This invention consists in separating the top from the sides of the crown, so that the tip, or top crown, may be either raised or let down at pleasure, in order to admit the external air, or to exclude it from circulating in the crown of the hat. The whole contrivance is effected by means of springs, sliders, sockets, grooves, loops, and cases, which are connected with the top and side-crown: thus the admission or exclusion of atmospheric air in front, behind, or on either side, may be regulated accordingly. See Repertory, vol. iv. and x.

Another patent was granted for the same thing to Messrs. Walker and Alphey, in the year 1801.

Hats are also made for women's wear, of chips, straw, or cane, by platting, and sewing the plats together; beginning with the centre of the crown, and working round till the whole is finished. Hats for the same purpose are also woven, and made of horse hair, silk, &c. There are few manufactures in which so little capital is wanted, or the knowledge of the art so soon acquired, as in that of straw-platting. One guinea is quite sufficient for the purchase of the machines and materials for employing one hundred persons for several months.

The straw is cut at the joints; and the outer covering being removed, it is sorted of equal sizes, and made up into bundles of eight or ten inches in length, and a foot in circumference. They are then to be dipped in water, and shaken a little so as not to retain too much moisture; and then the bundles are to be placed on their edges, in a box which is sufficiently close to prevent the evaporation of smoke. In the middle of the box is an earthen dish containing brimstone broke in small pieces: this is set on fire, and the box covered over and kept in the open air several hours.

It will be the business of one person to split and select the straws for fifty others who are braiders. The splitting is done by a small machine made principally of wood. The straws, when split, are termed splints, of which each worker has a certain quantity: on one end is wrapped a linen cloth, and they are held under the arm, and drawn out as wanted.

Platters should be taught to use their second fingers and thumbs, instead of the fore-fingers, which are often required to assist in turning the splints, and very much

facilitate the platting; and they should be cautioned against wetting the splints too much. Each platter should have a small linen work-bag, and a piece of pasteboard to roll the plat round. After five yards have been worked up, it should be wound about a piece of board half a yard wide, fastened at the top with yarn, and kept there several days to form it in a proper shape. Four of these parcels, or a score, is the measurement by which the plat is sold.

HATCHEL, HACKLE, or HITCHEL, a tool with which flax and hemp are combed into fine hairs. It consists of long iron pins, or teeth, regularly set in a piece of board.

There are several sorts of hatchels, each finer than the other, with which flax and hemp are prepared for spinning.

HATCHES, in a ship, a kind of trap-doors between the main-mast and fore-mast, through which all goods of bulk are let down into the hold.

HATCHES also denote flood-gates set in a river, &c. to stop the current of the water; particularly certain dams or mounds made of rubbish, clay, or earth, to prevent the water that issues from the stream-works and tin-washes in Cornwal, from running into the fresh rivers.

HATCHING, the maturating fecundated eggs, whether by the incubation and warmth of the parent bird, or by artificial heat, so as to produce young chickens alive.

The art of hatching chickens by means of ovens has long been practised in Egypt; but it is there only known to the inhabitants of a single village named Berme, and to those who live at a small distance from it. Towards the beginning of autumn they scatter themselves all over the country, where each person among them is ready to undertake the management of an oven, each of which is of a different size, but in general they are capable of containing from forty to fourscore thousand eggs. The number of these ovens placed up and down the country is about three hundred and eighty-six, and they usually keep them working for about six months: as therefore each brood takes up in an oven, as under a hen, only twenty-one days, it is easy in every one of them to hatch eight different broods of chickens. Every Bermean is under the obligation of delivering to the person who intrusts him with an oven, only two-thirds of as many chickens as there have been eggs put under his care; and he is a gainer by this bargain, as more than two-thirds of the eggs usually produce chickens. In order to make a calculation of the number of chickens yearly so hatched in Egypt, it has been supposed that only two-thirds of the eggs are hatched, and that each brood consists of at least thirty thousand chickens; and thus it would appear that the ovens of Egypt give life yearly to at least ninety-two millions six hundred and forty thousand of these animals.

This useful and advantageous method of hatching eggs has been employed in France, by the ingenious Mr. Reaumur, who, by a number of experiments, reduced the art to certain principles. He found by experience that the heat necessary for this purpose is nearly the same with that marked 32 on his thermometer, or that marked 96 on Fahrenheit's. This degree of heat is nearly that of the skin of the hen, and what is remarkable, of the skin of all other domestic fowls, and probably of all other kinds of birds. The degree of heat which brings about the developement of the cygnet, the gosling, and the turkey-pout, is the same as that which fits for hatching the canary-songster, and, in all probability, the smallest humming-bird: the difference is only in the time during which this heat ought to be communicated to the eggs of different birds: it will bring the canary-bird to perfection in eleven or twelve days, while the turkey-pout will require twenty-seven or twenty-eight.

Mr. Reaumur invented a sort of low boxes, without bottoms, and lined with furs. These, which he calls artificial parents, not only shelter the chickens from the injuries of the air, but afford a kindly warmth, so that they presently take the benefit of their shelter as readily as they would have done under the wings of a hen. After hatching, it will be necessary to keep the chickens for some time in a room artfully heated, and furnished with these boxes; but afterwards they may be safely exposed to the air in the court-yard, in which it may not be amiss to place one of these artificial parents to shelter them if there would be occasion for it.

As to the manner of feeding the young brood, they are generally a whole day after being hatched before they take any food at all; and then a few crumbs of bread may be given them for a day or two, after which they will begin to pick up insects and grass for themselves. But to save the trouble of attending them, capons may be taught to watch them in the same manner as hens do. Mr. Reaumur assures us that he has seen above two hundred chickens at once, all led about and defended only by three or four such capons. Nay, cocks may be taught to perform the same office, which they, as well as the capons, will continue to do all their lives after.

HATCHING, or *Haching*, in designing, &c. the making of lines with a pen, pencil, or graver, or the like; and the intersecting or going across those lines with others drawn a contrary way, is called counter-hatching. The depths and shadows of draughts are usually formed by hatching.

HATTOCK, a shock of corn containing twelve sheaves: others make it only three sheaves laid together.

HAUL, or HALE, an expression peculiar to seamen, implying to pull a single rope, without the assistance of blocks or other such mechanical powers. To haul the wind, is to direct the ship's course nearer to that point of the compass from which the wind arises.

HAUTBOY, a musical instrument of the wind-kind, shaped much like the flute, only that it spreads and widens towards the bottom, and is sounded through a reed. The treble is two feet long; the tenor goes a fifth lower, when blown open: it has only eight holes; but the bass, which is five feet long, has eleven.

HAWK. See FALCO.

HAWKERS and PEDLARS, are such dealers or itinerary petty chapmen as travel to different fairs or towns with goods or wares, and are placed under the control of commissioners, by whom they are licensed for that purpose pursuant to stat. 8 and 9 W. III. c. 25. and 29 Geo. III. c. 26. Traders in linen and woollen manufactories sending their goods to markets and fairs, and selling them by wholesale; manufacturers selling their own manufactures, and makers and sellers of English bone-

lace going from house to house, &c. are excepted out of the acts, and not to be taken as hawkers.

HAWKING. See FALCONRY.

HAWSER, in the sea-language, a large rope, or a kind of small cable, serving for various uses aboard a ship, as to fasten the main and fore shrouds, to warp a ship as she lies at anchor, and wind her up by a capstern, &c. The hawser of a man of war may serve for a cable to the sheet-anchor of a small ship.

HAWSES, in a ship, are two large holes under the bow, through which the cables run when she lies at anchor. Thus the Hawse-pieces are the large pieces of timber in which these holes are made. Hawse-bags, are bags of canvas made tapering, and stuffed full of oakum; which are generally allowed small ships, to prevent the sea from washing in at these holes: and hawse-plugs are plugs to stop the hawses, to prevent the water from washing into the manger.

There are also some terms in the sea-language that have an immediate relation to the hawses. Thus a bold hawse, is when the holes are high above the water. Fresh the hawse, or veer out more cable, is used when part of the cable that lies in the hawse is fretted or chafed, and it is ordered that more cable may be veered out, so that another part of it may rest in the hawses. Fresh the hawse, that is, lay new pieces upon the cable in the hawses, to preserve it from fretting. Burning in the hawse, is when the cables endure a violent stress. Clearing the hawses, is disentangling two cables that come through different hawses. To ride hawse-full, is when in stress of weather the ship falls with her head deep in the sea, so that the water runs in at the hawses.

HAY, any kind of grass, cut and dried, for the food of cattle. See HUSBANDRY.

HAZARD: a game on dice, without tables, is very properly so called, since it speedily makes a man, or undoes him.

It is played with only two dice; and as many may play it as can stand round the largest round table.

Two things are chiefly to be observed, viz. main and chance; the latter belonging to the caster, and the former, or main, to the other gamesters. There can be no main thrown above nine, nor under five; so that five, six, seven, eight, and nine, are the only mains flung at hazard. Chances and nicks are from four to ten: thus four is a chance to nine, five to eight, six to seven, seven to six, eight to five; and nine and ten a chance to five, six, seven, and eight: in short, four, five, six, seven, eight, nine, and ten are chances to any main, if any of these nick it not. Now nicks are either when the chance is the same with the main, as five and five, or the like; or six and twelve, seven and eleven, eight and twelve. Here observe, that twelve is out to nine, seven, and five; eleven is out to nine, eight, six, and five; and ames-ace and deuce-ace are out to all mains whatever.

But to illustrate this game by a few examples: Suppose the main to be seven, and the caster throws five, which is his chance; he then throws again, and if five turn up, he wins all the money set him; but if seven is thrown, he must pay as much money as there is on the board: again, if seven is the main, and the caster throws eleven, or a nick, he sweeps away all the money on the table; but if he throws a chance, as in the first case, he must throw again: lastly, if seven is the main, and the caster throws ames-ace, deuce-ace, or twelve, he is out; but if he throws from four to ten, he has a chance; though they are accounted the worst chances on the dice, as seven is reputed the best and easiest main to be flung. Four and five are bad throws (the former of which being called by the tribe of nickers little dick-fisher), as having only two chances, viz. trey-ace and two deuces, or trey-deuce and quartre-ace: whereas seven has three chances, viz. cinque-deuce, sice-ace, and quartre-trey. Nine and ten are in the like condition with four and five, having only two chances. Six and eight have indeed the same number of chances with seven, viz. three; but experienced gamesters nevertheless prefer the seven, by reason of the difficulty to throw the doublets, two quarters, or two treys. It is also the opinion of most, that at the first throw the caster has the worst of it. On the whole, hazard is certainly one of the most bewitching and ruinous games played on the dice. Happy, therefore, the man who either never heard of it, or who has resolution enough to leave it off in time.

HAZEL. See CORYLUS.

HEAD. See ANATOMY.

HEAD. See ARCHITECTURE.

HEAD, in heraldry. The heads of men, beasts, or birds, are very frequent in armoury; and borne either full-faced, looking forward, or side-faced in profile, when only one half of the face appears, which differences ought to be mentioned in blazoning, to avoid mistakes; as a head, or heads fronting; or a head, or heads side-faced, or in profile: thus, vert, a chevron gules, between three turks'-heads couped side-faced proper, is borne by the name of Smith. And again, or, a cross gules, between four blackmoors' heads, couped at the shoulders proper, is borne by the name Juxon. As the head is the principal part of the body, so it is of course the noblest bearing.

Among medalists, the different heads on ancient coins, are distinguished by the different dresses. See MEDAL.

In the imperial medals, where the head is quite bare, it is usually a sign the person was not an emperor, but one of the children of an emperor, the presumptive heir of the empire. The heads which are covered, are either covered with a diadem, or a crown, or a simple cork, or a veil, with some other foreign covering, whereof the diadem is the most ancient. The heads of deities are distinguished by some special symbol.

HEAD-ACHE. See MEDICINE.

HEADBORROW, or HEADBOROUGH, the chief of the frankpledge, and he that had the principal government of them within his own pledge. And as he was called headborrow, so was he called burrowhead, bursholder, thirdborrow, tithingham, chief-pledge, or borrow-elder, according to the diversity of terms in several places. The same officer is now occasionally called a constable. The headborough was the chief of the ten pledges: the other nine were called hardboroughs, or inferior pledges.

HEAD-LINES, in a ship, those ropes of all sails which are next to the yards, and by which the sails are made fast to the yards.

HEAD-SEA, is when a great wave or billow of the sea comes right ahead of the ship, as she is in her course.

HEAD-SAILS, in a ship, those which belong to the fore-

mast and boltsprit: for it is by these that the head of the ship is governed, and made to fall off and keep out of the wind; and these in quarter-winds are the chief drawing sails.

Head *of a ship*, or other vessel, is the prow, or that part which goes foremost.

Dragon's Head, in astronomy, &c. is the ascending node of the moon, or other planet. See Node.

HEARING, the sense whereby we perceive sounds. See Anatomy, Physiology, and Sounds.

HEARSAY, is generally not to be admitted as evidence; for no evidence is to be allowed but what is upon oath; for if the first speech was without oath, another oath that there was such speech, makes it no more than a bare speaking, and so of no value in a court of justice; and besides, the adverse party has no opportunity of a cross-examination; and if the witness is living, what he has been heard to say is not the best evidence that the nature of the thing will admit. But in some cases hearsay evidence is allowed to be admissible; as to prove who was a man's grandfather, when he married, what children he had, and the like; of which it is not reasonable to presume that there is better evidence. So in questions of prescription, it is allowed to give hearsay evidence, in order to prove general reputation; as where the issue was of a right to a way over the plaintiff's close, the defendant was admitted to give evidence of a conversation between persons not interested, then dead, wherein the right to the way was agreed. Theory of Evid. III. See Evidence.

HEARSE. See Hind.

HEART. See Anatomy.

HEAT, in physiology. See Caloric.

Heat, *Animal.* See Respiration.

Heat, in geography, the diversity of the heat of climates and seasons arising chiefly from the different angles under which the sun's rays strike upon the surface of the earth. Dr. Halley gives a mathematical computation of the effect of the sun under the different seasons and climates. Let it, however, be considered, that the different degrees of heat and cold in different places depend in a very great measure upon the accidents of situation, with regard to mountains and valleys, and the soil. The first greatly helps to chill the air by the winds which come over them, and which blow in eddies through the levels beyond; and mountains, sometimes turning a concave side to the sun, have the effects of a burning mirror upon the subject plain; and the like effect is sometimes had from the convex parts of clouds, either by refraction, or reflection. As to soils, a stony, sandy, or chalky earth, it is known, reflects most of the sun's rays into the air again, and retains but few, by which means a considerable accession of heat is derived to the air; as, on the contrary, black loose soils absorb most of the rays, and return few into the air, so that the ground is much the hotter.

The following table of the heat of different climates is computed for every tenth degree of latitude, to the equinoctial and tropical sun; by which an estimate may be made of the intermediate degrees.

Lat.	Sun in ♈ ♎	Sun in ♋	Sun in ♑
0	20000	18341	18341
10	19696	20290	15854
20	18797	21737	13166
30	17321	22651	10124
40	15321	23048	6944
50	12855	22991	3798
60	10000	22773	1075
70	6840	23543	000
80	3473	24673	000
90	0000	25055	000

Hence are deducible the following corollaries. 1. That the equinoctial heat, when the sun becomes vertical, is as twice the square of the radius, which may be proposed as a standard to compare with in all other cases. 2. That under the equinoctial, the heat is as the sine of the sun's declination. 3. That in the frigid zones, where the sun sets not, the heat is as the circumference of a circle into the sine of the altitude at 6; and consequently that in the same latitude these aggregates of warmth are as the sine of the sun's declination; and at the same declination of the sun, they are as the sines of the latitudes into the signs of the declination. 4. That the equinoctial day's heat is every where as the cosine of the latitude. 5. In all places where the sun sets, the difference between the summer and winter heats, when the declinations are contrary, is equal to a circle into the sine of the altitude at 6 in the summer parallel; and consequently these differences are as the sine of the latitude into or multiplied by the sines of declination. 6. From the foregoing table, it appears that the tropical sun under the equinoctial, has of all others the least force. Under the pole, it is greater than any other day's heat whatever; being to that of the equinoctial as 5 to 4.

HEATH. See Erica.

HEBENSTRETIA, a genus of the angiospermia order, in the didynamia class of plants; and in the natural method ranking under the 48th order, aggregatæ. The calyx is emarginated, and divided below; the corolla unilabiate; the lip rising upwards, and quadrifid; the capsule dispermous; the stamina inserted into the margin of the limb of the corolla. There are six species, herbs of the Cape.

HECATOMBÆON, in ancient chronology, the first month of the Athenian year, consisting of thirty days, and answering to the latter part of our June and beginning of July.

HECTIC, or Hectic Fever. See Medicine.

HEDERA, Ivy, a genus of the monogynia order, in the pentandria class of plants; and in the natural method giving name to the 46th order, hederaceæ. There are five oblong petals; the berry is pentaspermous, girt by the calyx There are six species; the most remarkable are: 1. The helix, or common ivy, which grows naturally in many parts of Britain; and, where it meets with any support, will rise to a great height, sending out roots on every side, which strike into the joints o walls or the bark of trees. If there is no support, they trail on the ground, and take root all their length, so that they closely cover the surface, and are difficult to eradicate. While these stalks are fixed to any support,

or trail upon the ground, they are slender and flexible; but when they have reached to the top of their support, they shorten and become woody, forming themselves into large bushy heads; and their leaves are larger, more of an oval shape, and not divided into lobes like the lower leaves, so that it has a quite different appearance. There are two varieties of this species; one with silver-striped leaves, the other with yellowish leaves on the tops of the branches; and these are sometimes admitted into gardens. 2. The quinquefolia, or Virginia creeper, is a native of all the northern parts of America. It was first brought to Europe from Canada; and has been long cultivated in the British gardens, chiefly to plant against walls or buildings to cover them: which these plants will do in a short time; for they will shoot almost twenty feet in one year, and will mount up to the top of the highest buildings; but as the leaves fall off in autumn, the plants make but an indifferent appearance in winter, and therefore are proper only for such situations as will not admit of better plants; for this will thrive in the midst of cities, and is not injured by the smoke or the closeness of the air.

The roots of the ivy are used by leather-cutters to whet their knives upon. Apricots and peaches covered with ivy during the month of February, have been observed to bear fruit plentifully. The leaves have a nauseous taste; Haller says, they are given to children in Germany, as a specific for the atrophy. The common people of England apply them to issues; and an ointment made from them is in great esteem among the Highlanders of Scotland as a ready cure for burns. The berries have a little acidity. In warm climates, a resinous juice exudes from the stalks, which is said to be a powerful resolvent, and an excellent ingredient in plasters and ointments. Horse and sheep eat the plant; goats and cows refuse it.

HEDGE-Breakers, by 43 Eliz. c. 7. shall pay such damages as a justice of the peace shall think fit; and on nonpayment shall be whipped. And by 15 Car. II. c. 6. the constable may apprehend a person suspected, and by warrant of a justice, may search his houses and other places; and if any hedge-wood shall be found, and he shall not give a good account how he came by the same, he shall be adjudged the stealer thereof.

HEDGES. See Husbandry.

HEDWIGEN, a genus of the octandria monogynia class and order. The cal. is four-toothed; the cor. four-cleft; style none; caps. tricoccous; seed a nut. There is one species, a tree of St. Domingo.

HEDYCARYA, a genus of the icosandria order, in the diœcia class of plants. The calyx of the male is cleft in eight or ten parts; there is no corolla, nor are there any filaments; the antheræ are in the bottom of the calyx, four-furrowed, and bearded at top. The calyx and corolla of the female are as in the male; the germs pedicellated; the nuts pedicellated and monospermous. There is one species, a tree of Guiana.

HEDYCREA, a genus of the class and order pentandria monogynia. The cal. is one-leafed, hemispherical, five-toothed: cor. none: drupe oval, one-celled: nect. ovate, covered with fibres, one-celled; shell hard. There is one species, a tree of Guiana.

HEDYOSMUM, a genus of the class and order monœcia polyandria. The male is an ament with anthers; no cor. perianth. or filaments. The female has cal. three-toothed; cor. none; style one, three-cornered; berry three-cornered, one-seeded. There are two species, shrubs of Jamaica.

HEDYOTIS, a genus of the monogynia order, in the tetrandria class of plants; and in the natural method ranking under the 47th order, stellatæ. The corolla is monopetalous and funnel-shaped; the capsule is bilocular, polyspermous, inferior. There are eight species, herbs of Ceylon, &c.

HEDYPNOIS, a genus of the class and order syngenesia polygamia æqualis. The cal. is calycled, with short scales; seeds crowned with the calycle; recept. naked, hollow-dotted.

HEDYSARUM, a genus of the decandria order, in the diadelphia class of plants; and in the natural method ranking under the 32d order, papilionaceæ. The carina of the corolla is transversely obtuse; the seed-vessel a legumen with monospermous joints. There are 90 species of this plant, of which the most remarkable are: 1. The gyrans, or sensitive hedysarum, a native of the East Indies, where it is called burrum chundalli. It arrives at the height of four feet, and in autumn produces bunches of yellow flowers. The root is annual or biennial. It is a trifolious plant, and the lateral leaves are smaller than those at the end, and all day long they are in constant motion without any external impulse. They move up and down, and circularly. This last motion is performed by the twisting of the footstalks; and while the one leaf is rising, its associate is generally descending. The motion downwards is quicker and more irregular than the motion upwards, which is steady and uniform. These motions are observable for the space of 24 hours in the leaves of a branch which is lopped off from the shrub, if it is kept in water. If from any obstacle the motion is retarded, upon the removal of that obstacle it is resumed with a greater degree of velocity. 2. The coronarium, or common biennial French honeysuckle, has large deeply-striking biennial roots; upright, hollow, smooth, very branchy stalks, three or four feet high, with pinnated leaves; and from between the leaves proceed long spikes of beautiful red flowers, succeeded by jointed seed-pods. The first species, being a native of hot climates, requires the common culture of tender exotics; the second is easily raised from seed in any of the common borders, and is very ornamental.

HEEL. See Anatomy.

Heel, in the sea-language. If a ship leans on one side, whether she is aground or afloat, then it is said she heels astarboard, or aport; or that she heels offwards, or to the shore; that is, inclines more to one side than to another.

HEGIRA, in chronology, a celebrated epocha among the Mahometans. The event which gave rise to this epocha was the flight of Mahomet from Mecca, with his new proselytes, to avoid the persecution of the Koraischites; who, being then most powerful in the city, could not bear that Mahomet should abolish idolatry, and establish his new religion. This flight happened in the fourteenth year after Mahomet had commenced prophet: he retired to Medina, which he made the place of his residence.

HEIGHT, in geometry, is a perpendicular let fall from the vertex, or top, of any right-lined figure, upon the base or side subtending it. It is likewise the perpendicular height of any object above the horizon; and is found several ways; by two staffs, a plain mirror with the quadrant, theodolite, or some graduated instrument, &c.

The measuring of heights or distances is of two kinds: when the place or object is accessible, as when you can approach to its bottom; or inaccessible, when it cannot be approached.

PROB. I. *To measure an accessible height* AB, *by means of two staffs.* See plate LXXII. Miscel. fig. 111.

Let there be placed perpendicularly in the ground, a longer staff DE, likewise a shorter one FG, so that the observer may see A, the top of the height to be measured, over the ends D, F, of the two staffs; let FH and DC, parallel to the horizon, meet DE and AB in H and C; then the triangles FHD, DCA, shall be equiangular, for the angles at C and H are right ones: likewise the angle A is equal to FDH; wherefore the remaining angles are also equal. Therefore, as FH, the distance of the two staffs, is to HD, the excess of the longer staff above the shorter; so is DC, the distance of the longer staff from the tower, to CA, the excess of the height of the tower above the longer staff; and thence CA will be found by the rule of three. To which if the length DE be added, you will have the whole height of the tower BA.

Scholium. Another method may be occasionally contrived for measuring an accessible height; as by the given length of the shadow BD (fig. 112), I find out the height AB: for let there be erected a staff CE, perpendicularly, producing the shadow EF; then it will be as EF, the shadow of the staff, is to EC, the staff itself; so is BD, the shadow of the tower, to BA, the height. Though the plane on which the shadow of the tower falls, be not parallel to the horizon, yet if the staff be erected in the same plane, the rule will be the same.

PROB. II. *To measure an accessible height by means of a plain mirror.*

Let AB (fig. 113) be the height to be measured; let the mirror be placed at C, in the horizontal plane BD, at a known distance BC; let the observer go back to D, till he see the image of the summit in the mirror, at a certain point of it, which he must diligently mark; and let DE be the height of the observer's eye. The triangles ABC and EDC, are equiangular; for the angles at D and B are right angles; and ACB, ECD, are equal, being the angles of incidence and reflection of the ray AC; wherefore the remaining angles at A and E, are also equal. Therefore it will be, as CD is to DE, so is CB to BA.

The observer will be more exact, if, at the point D, a staff be placed in the ground perpendicularly, over the top of which the observer may see a point of the glass exactly in a line betwixt him and the tower.

In place of a mirror may be used the surface of water, which naturally becomes parallel to the horizon.

PROB. III. *To measure an accessible height by the geometrical quadrant, theodolite, &c.*

Let the angle C (fig. 114) be found. Then in the triangle ABC, right-angled at B (BC being supposed the horizontal distance of the observer from the tower), having the angle C, and the side BC, the required height will be found by the first case of plain trigonometry. Thus, suppose the angle C. 37° 24′, and the horizontal distance, BC, 116. then the proportion will be as R : T. ∠C :: CB : BA, the height.

The tangent altitude 37° 24′ - -	9.88341
Log. CB 116 - - - - - -	2.06446
Added	11.94787
Radius	10.00000
Height of the object AB 88.69	1.94787

Supposing the observation made on the top of the tower, and the height of the tower to be known, to find the distance of any object on the plane below; it is only the converse of the former case.

You may also, having the base and angles, easily find the hypothenuse AC, or how far it is from the top of the tower to the station, by the second case of right-angled triangles: and it is useful in many cases.

PROB. IV. *To measure an inaccessible height by the geometrical quadrant, &c. at two stations.*

Let the angle ACB be observed (fig. 115); let the observer go from C, to the second station D, in the right line BCD; and after measuring this distance CD, take the angle ADC likewise with the quadrant. Then in the triangle ACD, which is formed by the two visual rays AD, AC, and the distance of the two stations D and C, there is given the angle ADC, with the angle ACD, because the angle ACB was given before; therefore the remaining angle CAD is given likewise. But the distance of the stations C and D is also given; therefore by the second case of obliqueangled trigonometry, the side AC will be found. Wherefore, in the right-angled triangle ABC, all the angles and the hypothenuse AC are given; consequently by the third case of plain trigonometry, the height sought, AB, may be found; as also the distance of the station C, from AB, the perpendicular within the hill or inaccessible height.

Example. Suppose the angle at C 43° 30′, and the angle at D 32° 12′. and the distance CD, betwixt the two stations, 112 feet; then the angle DAC will be 11° 18′, and the angle CAB 46° 30′. Hence for CA, the proportion will be as S. ∠ DAC : DC : : S. ∠ D : CA.

The log. DC 112 - - - -	2.04922
Sine ∠ D 32° 12′ - - - -	9.72663
Added	11.77585
S. ∠DAC 11° 18′ - - - -	9.29214
CA = 304.6 - - - - -	2.48371

Then for AB, the height of the object, it will be as R : S. ∠ ACB :: CA : AB.

As radius - - - - - -	10.00000
is to the sine of 43° 30′ - - -	9.83781
so is CA 304.6 - - - - -	2.48371
to AB 209.7 - - - - -	2.32152

Lastly, for CB, the distance of the object from the nearest station, it will be as R : S. ∠ CAB : : CA : BC.

As radius - - - - - -	10.00000
is to the sine of CAB 46° 30′ - -	9.86056
so is CA 304.6 - - - - -	2.48371
to BC 221 - - - - -	2.34427

If the height of the tower is wanted, the angle BCF (fig. 116) may be found with the quadrant, which being taken from the angle ACB already known, the angle ACF will remain; but the angle FAC was known before; therefore the remaining angle AFC will be known. But the side AC was supposed found by the last problem; therefore in the triangle AFC, all the angles, and one of the sides AC, being known, AF the height of the tower above the hill may be found by trigonometry.

PROB. V. *To measure the distance of two places* A *and* B, *of which one,* A, *is acccssible, by the theodolite,* fig. 117.

Let there be erected at two points, A and C, (sufficiently distant), visible signs; then let the two angles BAC, BCA, be taken by the theodolite. Let the distance of the stations A and C be measured with a chain. Then the third angle being known, and the side AC; therefore, by the second case of oblique trigonometry, the distance required AB will be found.

PROB. VI. *To measure, by the theodolite, &c. the distance of two places, neither of which is accessible,* fig. 118.

Let two stations C and D be chosen, from each of which the places may be seen whose distance is sought; let the angles ACD, BCD, and likewise the angles BDC, BDA, CDA, be measured by the theodolite, &c. and the distance of the stations C and D be measured by a chain, or, if necessary, by the last problem. Now in the triangle ACD, there are given two angles ACD and ADC; therefore the third CAD is likewise given: moreover the side CD is given; therefore by the second case of oblique trigonometry, the side AD will be found. After the same manner, in the triangle BCD, from all the angles, and one side CD given, the side BD is found. Wherefore, in the triangle ADB, from the given sides DA and DB, and the angle ADB contained by them, the side AB (the distance sought) is found too by the fourth case of oblique-angled trigonometry. Note, that it is not necessary that the points A, B, C, and D, be in one plane, and that any triangle is in one plane.

HEIR, is he to whom lands, tenements, or hereditaments, by the act of God and right of blood, descend of some estate of inheritance. Co. Lit. 7. b.

HEIR *apparent.* Here we must observe, that no person can be heir until the death of his ancestor; yet in common parlance, he who stands nearest in degree of kindred to the ancestor, is called even in his life-time, heir apparent. Co. Lit. 8. n. The law also takes notice of an heir apparent, so far as to allow the father to bring an action of trespass for taking away his son and heir, the father being guardian by nature to his son, where any lands descended to him. Co. Lit. 37.

Heir-general: the heir-general, or heir at common law, is he who after his father's or ancestor's death has a right to, and is introduced into, all his land, tenements, and hereditaments; but he must be of the whole blood, not a bastard, alien, &c. None but the heir-general, according to the course of the common law, can be heir to a warrantry, or sue an appeal of the death of his ancestors. Co. Lit. 14.

Customary heir: a custom in particular places varying the rules of descent at common law is good; such is the custom of gravelkind, by which all the sons shall inherit, and make but one heir to their ancestor; but the general custom of gravelkind lands extends to sons only; but a special custom, that if one brother dies without issue, all his brothers may inherit, is good. Co. Lit. 140 a.

To prevent the wrong and injury to creditors by the alienation of the lands descended, &c. by 3 and 4 W. and M. c. 14. it is enacted, that in all cases where any heir at law shall be liable to pay the debt of his ancestor, in regard of any lands, tenements, or hereditaments descending to him, and shall sell, alien, and make over, the same before any action brought or process sued out against him, such heir at law shall be answerable for such debt or debts in action or actions of debt to the value of the said land so by him sold, alienated, or made over; in which case all creditors shall be preferred, as in actions against executors and administrators: and such execution shall be taken out upon any judgment or judgments so obtained against such heirs, to the value of the said land, as if the same were his own proper debts; saving that the lands, tenements, and hereditaments, bona fide aliened before the action brought, shall not be liable to such execution. Provided, that where any action of debt upon any specialty, is brought against any heir, he may plead reins per descent at the time of the original writ brought, or the bill filed against him; any thing therein contained to the contrary notwithstanding. And the plaintiff in such action may reply, that he had lands, tenements, or hereditaments, from his ancestor before the original writ brought, or the bill filed; and if upon issue joined thereupon, it is found for the plaintiff, the jury shall inquire of the value of the lands, tenements, or hereditaments so descended, and thereupon judgment shall be given, and execution shall be awarded as aforesaid; but if judgment is given against such heir, by confession of the action with the assets descended, or upon demurrer, or nihil dixit, it shall be for the debt and damages, without any writ to inquire of the lands, tenements, or hereditaments, so descended.

Before this statute, if the ancestor had devised away the lands, a creditor by specialty had no remedy, either against the heir or devisee. Abr. Eq. 149.

But by the said statute, it is enacted that all wills and testaments, limitations, dispositions, or appointments, of or concerning any manors, messuages, lands, tenements, or hereditaments, or of any rent, profit, term, or charge out of the same, whereof any person at the time of his decease shall be seized in fee simple, possession, reversion, or remainder, or have power to dispose of the same by his last will and testament, shall be deemed and taken only against such creditor as aforesaid, his heirs, successors, executors, administrators and assigns, and every of them, to be fraudulent, and clearly, absolutely, and utterly void, frustrate, and of none effect; any pretence, colour, feigned or presumed consideration, or any other matter or thing, to the contrary notwithstanding.

And for the means, that such creditors may be enabled to recover their said debts, it is farther enacted, that in the cases before-mentioned, every such creditor shall and may maintain his action of debt, upon his said bond and specialties, against the heir at law of such obligor, and such devisee and devisees jointly, by virtue of this act; and such devisee and devisees shall be liable and chargeable for a false plea by him or them pleaded, in the same manner as any heir should have been for false plea by

him pleaded, or for not confessing the lands or tenements to him descended.

Provided, that where there has been or shall be any limitation or appointment, devise or disposition, of any manors, messuages, lands, tenements, or hereditaments, for the raising or payment of any real or just debt, or any portion, sum, or sums of money, for any child or children of any person, other than the heir at law, in pursuance of any marriage-contract or agreement in writing bona fide made before such marriage; the same and every of them shall be in full force, and the same manors, &c. may be holden and enjoyed by every such person, his heirs, executors, administrators, and assigns, for whom the said limitation, appointment, devise, or disposition was made, and by his trustee, his heirs, executors, administrators, and assigns, for such estate or interest as shall be so limited or appointed, devised, or disposed, until such debt or debts, portion or portions, shall be raised, paid, and satisfied; any thing contained in this act to the contrary notwithstanding.

And it is further enacted by the said statute, that all and every devisee and devisees made liable by this act, shall be liable and chargeable in the same manner as the heir at law, by force of this act, notwithstanding the lands, tenements, and hereditaments to him or them devised, shall be aliened before the action brought.

In the construction of this statute it has been holden, that though a man is prevented thereby from defeating his creditors by will, yet any settlement or disposition he shall make in his life-time of his lands, whether voluntary or not, will be good against bond creditors; for that was not provided against by the statute, which only took care to secure such creditors from any imposition which might be supposed in a man's last sickness; but if he gave away his estate in his life-time, this prevented the descent of so much to the heir, and consequently took away their remedy against him, who was only liable in respect of the lands descended; and as a bond is no lien whatsoever on the lands in the hands of the obligor, much less can it be so when they are given away to a stranger. Abr. Eq. 149.

HEIRESS, is a female heir to a person having an estate of inheritance of lands. If there are more than one, they are called coheiresses, or rather, in legal expression, coheirs. The offence of stealing an heiress is founded on the statute 3 Hen. VII. c. 2. which enacts, that if any man shall, for lucre, take any woman, being maid, widow, or wife, and having substance either in goods or lands, or being heir apparent to her ancestor, contrary to her will, and afterwards she be married to such misdoer; or by his consent to another, or defiled; he, his procurors, and abbettors, and such as knowingly receive such woman, shall be deemed principal felons; and by 39 Eliz. c. 9. the benefit of clergy is taken away from principals, procurors, and accessaries before. And it is not material whether a woman so taken contrary to her will, be at last married or defiled with her own consent or not, if she were under the force at the time.

HEIR-LOOMS, are such goods and personal chattles as, contrary to the nature of chattles, shall go by special custom to the heir, along with the inheritance, and not the executor of the last proprietor.

HEISTERIA, a genus of the monogynia order, in the decandria class of plants, and in the natural method ranking under the 12th order, holoraceæ. The calyx is quinquefid, the petals five; the fruit is a plum on a very large-coloured calyx. There is one species, a tree of Martinico.

HELENIUM, *bastard sun-flower*, a genus of the polygamia superflua order, in the syngenesia class of plants, and in the natural method ranking under the 49th order, compositæ. The receptacle is naked in the middle; under the radius, paleaceous; the pappus consists of five short awns; the calyx is simple and multipartite; the florets of the radius semitrifid. The species are: 1. The autumnale, with spear-shaped narrow leaves. 2. The pubescens, with pointed, spear-shaped, sawed leaves. Both these are natives of North America, where they grow wild in great plenty. They rise to the height of seven or eight feet in good ground. The roots, when large, send up a great number of stalks, which branch toward the top; the upper part of the stalk sustains one yellow flower, shaped like the sun-flower, but much smaller, having long rays, which are jagged pretty deep into four or five segments. These plants may be propagated by seeds, or by parting their roots; the latter is generally practised in this country. The best season to transplant and part the old roots is in October, when their leaves are past, or in the beginning of March just before they begin to shoot. They delight in a soil rather moist than dry, provided it is not too strong, or does not hold the wet in winter.

HELEPOLIS, in the ancient art of war, a machine for battering down the walls of a place besieged, the invention of which is ascribed to Demetrius, the Poliorcete. Diodorus Siculus says, that each side of the helepolis was 405 cubits broad, and 90 in height; that it had nine stages, and was carried on four strong solid wheels eight cubits in diameter; that it was armed with large battering rams, and had two roofs capable of supporting them; that in the lower stages there were different sorts of engines for casting stones; and in the middle they had large catapultas for lancing arrows, and smaller in those above, with a number of expert men for working all these machines.

HELIÆA, in Grecian antiquity, was the greatest and most frequented court in Athens, for the trial of civil affairs. The judges who sat in it were at least fifty, but the more usual number was either two or five hundred. When causes of great moment were to be tried, it was customary to call in the judges of the other courts: sometimes a thousand were called in, and then two courts are said to have been joined: sometimes fifteen hundred or two thousand were called in, and then three or four courts met together. They had cognizance of civil affairs of the greatest weight and importance, and were not permitted to give judgment till they had taken a solemn oath to do it with impartiality, and to give sentence according to the laws, &c.

HELIACAL, in astronomy, a term applied to the rising or setting of the stars, or, more strictly speaking, to their emersion out of and immersion into the rays and superior splendor of the sun.

A star is said to rise heliacally, when after having been in conjunction with the sun, and on that account invisible, it comes to be at such a distance from him, as to be seen in the morning before sun-rising; the sun, by his

apparent motion, receding from the star towards the east: on the contrary, the heliacal setting is when the sun approaches so near a star as to hide it with his beams, which prevent the fainter light of the star from being perceived, so that the terms apparition and occultation would be more proper than rising and setting.

All the fixed stars in the zodiac, as also the superior planets, Mars, Jupiter, and Saturn, rise heliacally in the morning, a little before sun-rising, and a few days after they have set cosmically. Again, they set heliacally in the evening, a short time before their achronycal setting. But the moon, whose motion eastward is always quicker than the apparent motion of the sun, rises heliacally in the evening, after the new moon, and sets heliacally in the morning, when old and approaching to a conjunction with the sun.

The inferior planets, Venus and Mercury, which sometimes seem to go westward from the sun, and sometimes again have a quicker motion eastward, rise heliacally in the morning, when they are retrograde; but when direct in their motions, they rise heliacally in the evening. The heliacal rising or setting of the moon happens when she is 17° distant from the sun; but for the other planets 20° are required; and for the fixed stars more or less according to their magnitude.

HELIANTHUS, *the great sun-flower*, a genus of the polygamia frustanea order, in the syngenesia class of plants, and in the natural method ranking under the 49th order, compositæ. The receptacle is paleaceous and plane; the pappus diphyllous; the calyx imbricated; the scales standing a little out at the tops. There are 12 species, most of which are now very common in gardens, and are all of them natives of America. They are all very hardy, and will thrive in almost any soil or situation. They may be propagated either by seeds or by parting their roots, but most of them are annual. The Jerusalem artichoke belongs to this genus.

HELICOID PARABOLA, or the *parabolic spiral*, is a curve arising from the supposition that the common or Apollonian parabola is bent or twisted, till the axis come into the periphery of a circle, the ordinates still retaining their places and perpendicular positions with respect to the circle, all these lines still remaining in the same plane. Thus, the axis of a parabola being bent into the circumference BCDM (Plate LXXII. Miscell. fig. 119.), and the ordinates CF, DG, &c. still perpendicular to it, then the parabola itself, passing through the extremities of the ordinates, is twisted into the curve BFG, &c. called the helicoid, or parabolic spiral.

Hence all the ordinates CF, DG, &c. tend to the centre of the circle, being perpendicular to the circumference.

Also, the equation of the curve remains the same as when it was a parabola; viz. putting $x =$ any circular absciss BC, and $y =$ CF the corresponding ordinate, then is $px = y^2$, where p is the parameter of the parabola.

HELICONIA, a genus of the monogynia order, in the pentandria class of plants. The spatha is universal and partial; there is no calyx; the corolla has three petals, and the nectarium two leaves; the capsule is three grained. There are three species, beautiful herbaceous stove plants from South America and the West Indies.

HELICTERES, *the screw-tree*, a genus of the decandria order, in the gynandria class of plants, and in the natural method ranking under the 37th order, columniferæ. The calyx is monophyllous and oblique; there are five petals, and the nectarium consists of five petal-like leaflets; the capsules are intorted or twisted inwards. There are nine species, all natives of warm climates. They are shrubby plants, rising from five to fourteen feet in height adorned with flowers of a yellow colour. They are propagated by seeds, but are tender, and in cold countries must be kept in a stove during the winter.

HELIOCARPUS, a genus of the digynia order, in the dodecandria class of plants, and in the natural method ranking under the 37th order, columniferæ. The calyx is tetraphyllous; the petals four; the styles simple; the capsule bilocular, compressed, and radiated lengthwise on each side. There is one species, a tree of La Vera Cruz.

HELIOCENTRIC *latitude of a planet*, the inclination of a line drawn between the centre of the sun and the centre of a planet, to the plane of the ecliptic, which may be thus determined.

If the circle FGH (Plate LXXII. Miscell. fig. 121.) represent the orbit of the earth round the sun, and the inner one ANBn, be so placed as to incline to the plane of the other (on which account it appears in the form of an ellipsis), then when the planet is in the node n, it will appear in the ecliptic, and so have no latitude. But if it move to P, then, being seen from the sun, it will appear to decline from the ecliptic, or to have latitude; and the inclination of the line SP to the plane of the ecliptic, is called the planet's heliocentric latitude; the measure of which is the angle PS p, supposing the line P p to be perpendicular to the plane of the ecliptic.

This heliocentric latitude will be continually increasing till the planet come to the point A, which they call the limit or utmost extent of it; and then it will decrease again till it reach the other node N, when it will have no latitude; after which it will increase again, till it come to B, or its utmost latitude; and, lastly decrease again, till the planet come to be in n, whence it set out.

HELIOCENTRIC *place of a planet*, in astronomy, the place of the ecliptic in which the planet would appear to a spectator placed at the centre of the sun.

The ingenious Dr. Halley gives the following method to find the heliocentrical places of a planet, and its distances from the sun, which supposes only that the periodical time of the planet is known. Let KLB (fig. 120.) be the orbit of the earth, S the sun, P the planet, or rather the point in the plane of the ecliptic, in which the perpendicular let fall from the planet meets that plane. And first when the earth is in K, observe the geocentric longitude of the planet, and having the theory of the earth, we have the apparent longitude of the sun, and, consequently, the angle PKS. The planet after it has completed an entire revolution, returns again to the point P, at which time suppose the earth in L; and there again, let the planet be observed, and find the angle PLS, the planet's elongation from the sun. Having the times of observations, we have the places of the earth in the ecliptic, or the points K and L; and consequently, the angle LSK, and the sides LS and SK: wherefore we shall have the angles SKL and SLK, and the side LK. From the known angles SKP and SLP, take away the known angles SKL

and SLK, and we shall have the angles PKL and PLK known; therefore in the triangle PLK, having all the three angles, and the side LK, we shall find the side PL; and in the triangle PLS, having the sides PL and LS, and the intercepted angle PLS, we shall have the angle LSP, which determines the heliocentric place, and its distance from the node according to the ecliptic, as also the side SP. But as the tangent of the geocentric latitude is to the tangent of the heliocentric, so is the curtate distance of the planet from the sun to its curtate distance from the earth. But as the geocentric latitude may be found by observation, the heliocentric latitude will also be found; by which, and the curtate distance of the planet from the sun, we can find the true distance.

HELIOCOMETES, a phenomenon sometimes observed about sun-setting; being a large luminous tail or column of light proceeding from the body of the sun, and dragging after it, not unlike the tail of a comet; whence the name.

HELIOPHILA, a genus of the siliquosa order, in the tetradynamia class of plants, and in the natural method ranking under the 39th order, siliquosæ. There are two nectaria recurvated towards the vesicular base of the calyx. There are ten species, all herbaceous plants of the Cape.

HELIOSCOPE, in optics, a sort of a telescope, peculiarly fitted for viewing the sun, without hurting the eyes. See OPTICS.

As the sun may be viewed through coloured glasses, without hurt to the eyes, if the object and eye-glasses of a telescope are made of coloured glass, as red or green, such a telescope will become an helioscope. But Mr. Huygens only used a plain glass, blacked at the flame of a candle on one side, and placed between the eye-glass and the eye, which answers the design of an helioscope very well.

HELIOSTATA, in optics, an instrument invented by the late learned Dr. S. Gravesande, who gave it this name, from its fixing apparently the rays of the sun in an horizontal direction across the dark chamber, all the while it is in use.

HELIOTROPE, a precious stone of a green colour, streaked with red veins. Pliny says it is thus called, because, when cast into a vessel of water, the sun's rays falling on it seem to be of a blood-colour; and that, when out of the water, it gives a faint reflection of the figure of the sun, and is proper to observe eclipses of the sun as a helioscope. The heliotrope is also called oriental jasper, on account of its ruddy spots. It is found in the East Indies, as also in Ethiopia, Germany, &c. According to Dr. Thompson, the colour of this stone is different shades of green, often stained or striped with olive, yellow, and red. Found in mass, and in angular pieces. Specific gravity 2.6. Brittle, infusible before the blow-pipe.

HELIOTROPIUM, *turnsole*, a genus of the polygynia order, in the pentandria class of plants, and in the natural method ranking under the 41st order, asperifoliæ. The corolla is salver-shaped and quinquefid, with lesser dents interjected alternately; the throat closed up by small arches formed in the corolla itself. There are 24 species, all of them natives of warm countries. Only one, called the tricoccum, grows in Europe, and is a native of France, Spain, and Italy. It is only remarkable for the property of its berries. See COLOUR-MAKING.

HELIX, in geometry, the same with spiral. In architecture some authors make a difference between the helix and the spiral. A stair-case, according to Daviler, is an helix, or is helical, when the stairs or steps wind round a cylindrical newel; whereas the spiral winds round a cone, and is continually approaching nearer and nearer its axis.

HELIX, *the snail*, in zoology, a genus belonging to the order of vermes testacea. The shell consists of one spiral, brittle, and almost diaphanous valve; and the aperture is narrow. There are 60 species, principally distinguished by the figure of their shells. They are of various sizes, from that of a small apple to less than half a pea. Some of them live on land, frequenting woods and gardens, or inhabiting clefts of rocks and dry sand-banks. Others of them are aquatic, inhabiting ponds, deep rivers, and the ocean. The principal species are,

The janthina, with a violet-coloured shell, is remarkable for the extreme thinness of its texture, which breaks with the least pressure, and seems therefore entirely calculated to keep the open sea, or at least to shun rocky shores. It inhabits the seas of Europe, especially the Mediterranean, those of Asia and Africa, and also the ocean. The living animal, when touched, exudes a juice which stains the hands of a violet-colour. Dr. Hawkesworth, in his Account of Cooke's Voyage, mistakes this shell for that which yielded the purpura of the ancients. But whoever looks into Pliny, can never have the least idea that the thin shell aforementioned could be the same with it. They had several shells which yielded the purple dye; but these were all rock-shells, and very different both in figure and hardness from the little helix janthina, which is not calculated for the neighbourhood of rocks.

2. The pomatia, or exotic snail, with five spires, most remarkably ventricose, and fasciated with a lighter and deeper brown, is a native of France, where it inhabits the woods, but has been naturalized in England, where it inhabits the woods in the southern counties. It was introduced, it is said; by sir Kenelm Digby, whether for medical purposes, or as food, is uncertain: tradition says, that to cure his beloved wife of a decay was the object. They are quite confined to the southern counties. An attempt was made to bring them into Northamptonshire, but they would not live there. These are used as a food in several parts of Europe during Lent, and are preserved in an escargatoire, or a large place boarded in, with a floor covered half a foot deep with herbs, in which the snails nestle and fatten. They were also a favourite dish with the Romans, who had their cochlearia, a nursery similar to the above. Fulvius Hirpinus was the first inventor of this luxury, a little before the civil wars between Cæsar and Pompey. The snails were fed with bran and sodden wine. If we could credit Varro, they grew so large that the shells of some would hold ten quarts! People need not admire the temperance of the supper of the younger Pliny, which consisted of only a lettuce. three snails. two eggs. a barley-cake, sweet wine and snow, in case his snails bore any proportion in size

to those of Hirpinus. Its name is derived not from any thing relating to an orchard, but from πωμα, an operculum, it having a very strong one. This seems to be the species described by Pliny, lib. viii. c. 39. which he says was scarce; that it covered itself with the opercle, and lodged under ground; and that they were at first found only about the maritime Alps, and more lately near Velitræ.

3. The hortensis, or garden-snail, is in form like the last, but less, and not umbilicated and clouded, or mottled with browns. It abounds with a viscid slimy juice, which it readily gives out by boiling in milk or water, so as to render them thick and glutinous. The decoctions in milk are apparently very nutritious and demulcent, and have been recommended in a thin acrimonious state of the humours, in consumptive cases and emaciations.

The eyes of snails are lodged in their horns, one at the end of each horn, which they can retract at pleasure. The manner of examining these eyes, which are four in number, is this: When the horns are out, cut off nimbly the extremity of one of them; and placing it before the microscope, you may discover the black spot at the end to be really a semiglobular eye. The dissection of this animal is very curious; for by this means the microscope not only discovers the heart beating just against the round hole near the neck, which seems the place of respiration, but also the liver, spleen, stomach, and intestines, with the veins, arteries, mouth and teeth, are plainly observable. The intestines of this creature are green, from its eating herbs, and are branched all over with fine capillary white veins; the mouth is like a hare's or rabbit's, with four or six needle-teeth, resembling those of leeches, and of a substance like horn. Snails are all hermaphrodites, having both sexes united in each individual. They lay their eggs with great care in the earth, and the young ones are hatched with shells completely formed. Cutting off a snail's head, a little stone appears, which is supposed to be a great diuretic, and good in all nephritic disorders. Immediately under this stone the heart is seen beating: and the auricles are evidently distinguishable, and are membranous, and of a white colour: as are also the vessels which proceed from them.

Snails discharge their excrements at a hole in their neck; they also breathe by this hole, and their parts of generation are situated very near it.

So small an animal as the snail is not free from the plague of supporting other smaller animals on its body; and as in other animals we find these secondary ones either living on their surface, as lice, &c. or only in the intestines, as worms, it is very remarkable that the snail is infested in both these manners, lice being found sometimes on the surface of its body, and worms sometimes within its intestines. There is a part of the common garden snail, and of other of the like kinds, commonly called the collar. This surrounds the neck of the snail, and is considerably thick, and is the only part that is visible when the animal is retired quietly into its shell. In this state of the animal these insects which infest it are usually seen in considerable numbers marching about very nimbly on this part; besides, the snail, every time it has occasion to open its anus, gives them a place by which to enter into its intestines, and they often seize the opportunity.

Snails are great destroyers of fruit in our gardens, especially the better sorts of wall-fruit. Lime and ashes sprinkled on the ground where they most resort will drive them away, and destroy the young brood of them. It is a common practice to pull off the fruit they have bitten; but this should never be done, for they will eat no other till they have wholly eaten up this if it is left for them. See Plate LXVII. Nat. Hist. fig. 223.

Helix. See Anatomy.

HELLEBORUS, *hellebore*, a genus of the polygynia order, in the polyandria class of plants, and in the natural method ranking under the 26th order, multisiliquæ. There is no calyx; but 5 or more petals; the nectaria are bilabiated and tubular; the capsules polyspermous, and a little erect. There are seven species, the most remarkable of which is the niger, commonly called Christmas-rose. It has roots composed of many thick fleshy spreading fibres, crowned by a large cluster of lobed leaves, consisting each of seven or eight obtuse fleshy lobes, united to one foot-stalk; and between the leaves several thick fleshy flower-stalks, three or four inches high, surmounted by large beautiful white flowers, of five roundish petals, and numerous filaments, appearing in winter, about or soon after Christmas.

This plant may be propagated either by seeds or parting the roots. It prospers in the open borders, or may be planted in pots to move when in bloom, in order to adorn any particular place; but it always flowers fairest and most abundantly in the front of a warm sunny border. The plants may be removed, and the roots divided for propagation, in September, October, or November; but the sooner in autumn it is done, the stronger will the plants flower at their proper season.

The root of this plant was anciently used as a cathartic. The taste of it is acrid and bitter. Its acrimony, as Dr. Grew observes, is first felt on the tip of the tongue, and then spreads itself immediately to the middle, without being much perceived in the intermediate part. On chewing the root for a few minutes, the tongue seems benumbed, and affected with a kind of paralytic stupor, as when burnt by eating any thing too hot. The fibres are more acrimonious than the head of the root whence they issue. Black hellebore root, taken from 15 to 30 grains, proves a strong cathartic, and as such has been celebrated for the cure of maniacal disorders, and such also as were attributed to what the ancients called the atra bilis. In mania, however, this root appears by no means to be possessed of any specific power. It does not indeed appear that our black hellebore acts with so much violence as that of the ancients, whence many have supposed it to be a different plant; and indeed the descriptions which the antients have left us of their hellebore, do not agree with those of any of the sorts usually taken notice of by modern botanists. Another species has been discovered in the eastern countries, which Tournefort distinguishes by the name of helleborus niger orientalis, amplissimo folio, caule præalto, flore purpurascente, and supposes to be the true ancient hellebore, from its growing in plenty about Mount Olympus, and in the island of Anticyra, celebrated of old for the production of this antimaniacal drug: he relates, that a scruple of this sort given

for a dose, occasioned convulsions. Our hellebore is looked upon principally as in alterative; and is sometimes employed in small doses for promoting the uterine and urinary discharges, &c. It proves a powerful emmenagogue in plethoric habits, where steel is ineffectual or improper. In some parts of Germany a species of black hellebore has been made use of, which frequently produced violent, and sometimes deleterious effects. It appears to be the feted kind of Linnæus, called in English settlewort, setterwort, or bastard hellebore. The roots of this may be distinguished from those of the true kind, by their being less black.

2. The hyemalis, with a beautiful yellow flower, which is the common harbinger of spring.

HELM *of a ship*, is a piece of timber fastened into the rudder, which comes forward into the steerage, or place where the person at the helm steers the ship, by holding the whipstaff in his hand, where it joined to the helm. They begin, however, to be left off, steering-wheels being used in their room.

There are several terms in the sea language relating to the helm: as, bear up the helm; that is, let the ship go more large before the wind: helm a mid-ship or right the helm; that is, keep it even with the middle of the ship: port the helm, put it over to the left side of the ship: starboard the helm, put it on the right side of the ship. See SHIP-BUILDING.

HELMET, an ancient defensive armour worn by horsemen both in war and in tournaments. It covered both the head and face, only leaving an aperture in the front secured by bars, which was called the visor.

It is still used in heraldry by way of crest over the shield or coat of arms, in order to express the different degrees of nobility by the different manner in which it is borne. Thus a helmet in profile is given to gentlemen and esquires: to a knight, the helmet standing forward and the beaver a little open: the helmet in profile and open, with bars, belongs to all noblemen under the degree of a duke; and the helmet forward and open, with many bars, is assigned to kings, princes, and dukes. There is generally but one helmet upon a shield; but sometimes there are two, and even three: if there are two, they ought to face each other; and if three, the middlemost should stand directly forward, and the other two on the sides facing towards it.

HELMINTHOLITHUS, in natural history, a name given by Linnæus to petrified bodies resembling worms. Of these he reckons four genera. 1. Petrified lithophyta, found in the mountains of Sweden. 2. Petrified shells. 3. Petrified zoophytes. 4. Petrified reptiles. See LITHOPHYTA, &c.

HELONIAS, a genus of the trigynia order, in the hexandria class of plants, and in the natural method ranking under the 10th order, coronariæ. The corolla is hexapetalous; there is no calyx; and the capsule is trilocular. There are two species; herbs of America.

HELVELIA, a genus of the class and order cryptogamia fungi. There are two species, natives of this country.

HELXINE. See POLYGONUM.

HEMATOPUS, in ornithology, a genus of the grallæ order. The generic character is: the bill compressed, the lip an equal wedge; nostrils linear; tongue a third part as long as the bill; feet formed for running, three-toed, cleft.

The H. ostrolegus, or oyster-catcher, inhabits almost every sea-shore, is sixteen and a half inches long, feeds on marine worms and insects, but chiefly on oysters and limpets, which it extracts from the shell with great dexterity. Eggs, four or five; colour, olive-yellow, with irregular purplish spots. This is the only species. See Plate LXVII. Nat. Hist. fig. 219.

HEMEROBIUS, in zoology, a genus of insects of the neuroptera order, the characters of which are these: the mouth is furnished with two teeth; the palpi are four; the wings are deflected but not plaited; and the antennæ are bristly and longer than the breast. There are 15 species, principally distinguished by their colours. This insect takes the name of hemerobius from the shortness of its life, which, however, continues several days. In the state of larva it is a great devourer of plant-lice, for which it has had bestowed upon it the appellation of lion of the plant-lice. The hemerobii, even after their transformation, preserve their carnivorous inclination. Not satisfied with making war upon the plant-lice, who tamely let themselves be devoured, they do not spare each other. The eggs of this insect are borne upon small pedicles, which are nothing but a gum spun out by the hemerobius by raising up the hinder part of its abdomen, and by that means the egg remains fastened to the upper part of the thread. Those eggs are deposited upon leaves, and set in the form of bunches. They have been taken for parasitic plants. The larva, when hatched, finds there its food in the midst of plant-lice. In 15 or 16 days it has attained to its full growth. With its spinning-wheel at its tail, it makes itself a small, round, white, silky cod, of a close texture. In summer, at the end of three weeks, the hemerobius issues forth with its wings; but when the cod has not been spun till autumn, the chrysalis remains in it the whole winter, and does not undergo its final metamorphosis till the ensuing spring. The flight of this insect is heavy: some species have an excrementitious smell. One goes by the name of the water-hemerobius, because it lives mostly at the water-side. See Plate LXVII. Nat. Hist. fig. 224.

HEMEROCALLIS, *day-lily*, or *lily-asphodel*, a genus of the monogynia order, in the hexandria class of plants, and in the natural method ranking under the 10th order, coronariæ. The corolla is campanulated, with the tube cylindrical; the stamina declining downward. There are five species, of which two are common, viz.

1. The flava, or yellow day-lily, with strong fibrous roots, sending up large hollow keel-shaped leaves, two feet long, upright, leafless firm stalks, two feet high, dividing at top into several foot-stalks, each terminated by one large liliaceous yellow flower, of an agreeable odour. Of this there is a variety called the hemerocallis minor, or small yellow day-lily.

2. The fulva, reddish, or copper-coloured day-lily, has roots composed of strong fleshy fibres, and large oblong tubes; radical, keel-shaped, hollow, pointed leaves, a yard long, reflected at top, with leafless stalks, three or four feet high, and large copper-coloured liliaceous flowers. These have large stamina, charged with a kind of brown-coloured farina, which, on being touched

or smelled to, is discharged in great plenty all over the hands and face. Both these species are hardy, and will thrive any where. They may be easily propagated by parting their roots in autumn, or almost any time after flowering, or before they begin to flower.

3. The japonica is a greenhouse plant, producing beautiful white flowers.

HEMERODROMI, in Grecian antiquity, centinels and guards appointed for the security and preservation of cities and other places. They went out of the city every morning as soon as the gates were opened, and kept patrolling all day about the place: sometimes also making excursions further into the country, to see that there were no enemies lying in wait to surprise them.

Hemerodromi were also a sort of couriers among the ancients, who only travelled one day, and then delivered their packets or despatches to a fresh man, who run his day, and so on to the end of the journey.

HEMICYCLE. See Architecture.

HEMIMERIS, a genus of the angiospermia order, in the didynamia class of plants. The capsule is bilocular, with one of the cells more gibbous than the other; the corolla is wheel-shaped, with one division greater, and inverse heart-shaped; the interstice of the divisions nectar-bearing. There are three species, herbaceous plants of the Cape.

HEMINA, in Roman antiquity, a liquid measure which, according to Arbuthnot, was equal to half a wine-pint English measure; its contents being 2.818 solid inches.

HEMIONITIS, a genus of the natural order of filices, belonging to the cryptogamia class of plants. The fructifications are in lines, decussating or crossing each other. There are eight species, natives of the West Indies.

HEMIPLEGIA. See Medicine.

HEMIPTERA, derived from ἡμισυς, *half, wing,* πτερον, in the Linnæan system, the second order of insects, comprehending twelve genera, viz. the blatta, mantis, gryllus, fulgora, cicada, notonecta, nepa, cimex, aphis, chermes, coccus, and thrips, and a great number of species.

HEMISPHERE, in geometry, the half of a globe or sphere, when it is supposed to be cut through its centre in the plane of one of its great circles. Thus the equator divides the terrestrial globe into the northern and southern hemisphere: in the same manner the meridian divides the globe into the eastern and western hemisphere; and the horizon into two hemispheres, distinguished by the epithets upper and lower. The centre of gravity of an hemisphere is five-eights of the radius distant from the vertex.

Hemisphere is also used to denote a projection of half the terrestrial globe, or half the celestial sphere, on a plane, and frequently called planisphere.

HEMISTICH, in poetry, denotes half a verse, or a verse not completed. Of this there are frequent examples in Virgil's Æneid; but whether they were left unfinished by design or not, is disputed among the learned: such are *Ferro accincta vocat,* Æn. II. v. 614. And, *Italiam non sponte sequor,* Æn. IV. v. 361.

In reading common English verses, a short pause is required at the end of each hemistich, or half verse.

HEMLOCK. See Cicuta.

HEMP and Flax. No hemp or flax is to be watered in any river, running water, stream, brook, or pond, where beasts are used to be watered, but only in their several ponds for that purpose, on pain of 20*s*. 33 Hen. VIII. c. 17.

Any persons may, in any place, corporate town, privileged or unprivileged, set up manufactories of hemp or flax; and persons coming from abroad, using the trade of hemp or flax-dressing, and of making thread, weaving cloth made of hemp or flax, or making tapestry hangings, twine or nets for fishery, cordage, &c. after three years, shall have the privilege of natural-born subjects. 15 Car. II. c. 15.

HEN. See Phasianus.

HENDECAGON, in geometry, a figure that has eleven sides, and as many angles. In fortification, hendecagon denotes a place defended by eleven bastions.

HENOTICON, in church history, a decree or edict of the emperor Zeno, made at Constantinople, in the year 482, by which he pretended to reconcile all parties under one faith.

HEPAR, a name formerly given to the combination of sulphur and alkali. It is now called sulphuret of potass.

HEPATIC gas, the old name for the gas separated from sulphuret of alkali. It is now called sulphurated hydrogen gas.

HEPATICA. See Anemone.

HEPATITIS. See Medicine.

HEPTAGON, in geometry, a figure of seven sides and seven angles. When those sides and angles are all equal, the heptagon is said to be regular, otherwise it is irregular.

In a regular heptagon, the angle C, Plate LXXII. Miscel. fig. 122, at the centre is $= 51^\circ\frac{3}{7}$, the angle DAB of the polygon is $= 128^\circ\frac{4}{7}$, and its half CAB $= 64^\circ\frac{2}{7}$. Also the area is = the square of the side $AB^2 \times 3.6339124$, or $= AB^2 \times \frac{7}{4}t$, where t is the tangent of the angle CAB of $64^\circ\,\frac{2}{7}$ to the radius 1; or t is the root of the equation; $t^{12} - 26t^{10} + 143t^8 - 245t^6 + 143t^4 - 26t^2 + 1 = 0$; or $t = \sqrt{\frac{1+x}{1-x}} = \frac{1+\sqrt{1-y^2}}{y} = \frac{y}{1-\sqrt{1-y^2}}$, where the value of x and y are the roots of the equations

$$x^6 - \tfrac{5}{4}\,x^4 + \tfrac{3}{8}\,x^2 - \tfrac{1}{46} = 0,$$
$$y^6 = \tfrac{7}{4}\,y^4 + \tfrac{7}{8}\,y^2 - \tfrac{7}{64} = 0.$$

Heptagon, in Fortification, a place fortified or strengthened with seven bastions for its defence.

HEPTAGONAL Numbers, are a kind of polygonal numbers in which the difference of the terms of the corresponding arithmetical progression is 5. Thus,

Arithmeticals, 1, 6, 11, 16, 21, 26, &c.
Heptagonals, 1, 7, 18, 34, 55, 38, &c.

where the heptagonals are formed by adding continually the terms of the arithmeticals, above them, whose common difference is 5.

One property, among many others, of these heptagonal numbers is, that if any one of them be multiplied by 40, and to the product add 9, the sum will be a square number.

Thus $1 \times 40 + 9 = 49 = 7^2$;
and $7 \times 40 + 9 = 289 = 17^2$;
and $18 \times 40 + 9 = 729 = 27^2$;
and $34 \times 40 + 9 = 1369 = 37^2$; &c.

Where it is remarkable that the series of squares so formed is 7^2, 17^2, 27^2, 37^2, &c., the common difference of whose roots is 10, the double of the common difference of the arithmetical series from which the heptagonals are formed. See POLYGONALS.

HEPTAMERIS, in music, the seventh part of a meris, being, according to M. Sauveur, the forty-third part of the octave.

HEPTANDRIA, from ἑπτα, septem, and ανηρ, a man, the seventh class in Linnæus's sexual method, consisting of plants with hermaphrodite flowers, which have seven stamina or male organs. The orders are four, derived from the number of styles or female organs. See BOTANY.

HEPTANGULAR FIGURE, in geometry, is one that has seven angles, and therefore also seven sides.

HERACLEUM, a genus of the pentandria digynia class of plants, the general flower of which is difform and radiated; the single flowers of the disc consist each of five equal petals, but those of the radius consist of five unequal petals. The fruit is elliptic, compressed, and striated on each side in the middle, and contains two oval compressed seeds. To this genus belongs the sphondylium or cow's parsnep of authors. There are six species.

HERACLIDÆ, or *return of the* HERACLIDÆ *into Peloponnesus*, in chronology, a famous epocha, that constitutes the beginning of prophane history; all the time preceding that period being accounted fabulous. This return happened in the year of the world 2862, an hundred years after they were expelled, and eighty after the destruction of Troy.

HERALD, is an officer at arms, whose business is to denounce war, proclaim peace, or be otherwise employed by the king in martial messages or other business.

Heralds are the judges and examiners of gentlemen's coats of arms, and preservers of genealogies; and they marshal all solemnities at the coronation of princes, and funerals of great persons.

HERALDRY, the science which teaches how to blazon, or explain in proper terms, all that belongs to coats of arms; and how to marshal, or dispose regularly, divers arms on a field.

Arms, or coats of arms, are hereditary marks of honour, made up of fixed and determined colours and figures, granted by sovereign princes, as a reward for military valour, or some signal public service performed. These are intended to denote the descent and alliance of the bearer, or to distinguish states, cities, societies, &c. civil, ecclesiastical, and military.

Men in all ages have made use of figures of living creatures, or symbolical signs, to denote the bravery and courage either of their chief or nation, to render themselves the more terrible to their enemies, and even to distinguish themselves or families, as names do individuals. Thus the Egyptians bore an ox, the Athenians an owl, the Goths a bear, the Romans an eagle, the Franks a lion, and the Saxons a horse: the last is still borne in the arms of his present Britannic majesty. As to hereditary arms of families, William Camden, sir Henry Spelman, and other judicious heralds, agree, that they began no sooner than towards the latter end of the eleventh century.

With tournaments first came up coats of arms: which were a sort of livery, made up of several lists, fillets, or narrow pieces of stuff of many colours, from whence came the fess, the bend, the pale, &c. which were the original charges of family-arms: for they who never had been to tournaments had not such marks of distinction. They who enlisted themselves in the croisados took up also several new figures hitherto unknown in armorial ensigns; such as alerions, bezants, escalop-shells, martlets, &c. but more particularly crosses, of different colours for distinction's sake. From this it may be concluded, that heraldry, like most human inventions, was insensibly introduced and established; and that, after having been rude and unsettled for many ages, it was at last methodized, perfected, and fixed, by the croisades and tournaments.

These marks of honour are called arms, from their being principally and first worn by military men at war and tournaments, who had them engraved, embossed, or depicted on shields, targets, banners, or other martial instruments. They are also called coat of arms, from the custom of the ancients embroidering them on the coats they wore over their arms, as heralds do to this day.

Arms are distinguished by different names, to denote the causes of their bearing; such as arms of dominion; of pretension; of concession; of community; of patronage; of family; of alliance; of succession.

Arms of dominion, or sovereignty, are those which emperors, kings, and sovereign states do constantly bear; being annexed to the territories, kingdoms, and provinces, they possess. Thus the three lions are the arms of England, the harp those of Ireland, &c.

Arms of pretension are those of such kingdoms, provinces, or territories, to which a prince or lord has some claim, and which he adds to his own, although the said kingdom, or territories may be possessed by a foreign prince or lord. Thus the kings of England have quartered the arms of France with their own ever since Edward III. laid claim to the kingdom of France, which happened in the year 1330, on account of his being son to Isabella, sister to Charles the Handsome, who died without issue.

Arms of concession, or augmentation of honour, are either entire arms, or else one or more figures, given by princes as a reward for some extraordinary service. We read in history that Robert Bruce, king of Scotland, allowed the earl of Wintoun's ancestor to bear, in his coat-armour, a crown supported by a sword, to show that he, and the clan Seaton, of which he was the head, supported his tottering crown.

Arms of community are those of bishoprics, cities, universities, academies, societies, companies, and other bodies corporate.

Arms of patronage are such as governors of provinces, lords of manors, patrons of benefices, &c. add to their family-arms, as a token of their superiority, rights, and jurisdiction. These arms have introduced into heraldry, castles, gates, wheels, ploughs, rakes, harrows, &c.

Arms of family, or paternal arms, are those that belong to one particular family, that distinguish it from others,

and which no person is suffered to assume without committing a crime, which sovereigns have a right to restrain and punish.

Arms of alliance are those which families or private persons take up and join to their own, to denote the alliances they have contracted by marriage. This sort of arms is either impaled, or borne in an escutcheon of pretence, by those who have married heiresses.

Arms of succession are such as are taken up by them who inherit certain estates, manors, &c. either by will, entail, or donation, and which they either impale, or quarter with their own arms; which multiplies the titles of some families out of necessity, and not through ostentation, as many imagine.

These are the eight classes under which the different sorts of arms are generally ranged; but there is a sort which blazoners call assumptive arms, being such as are taken by the caprice or fancy of upstarts, though of ever so mean extraction, who, being advanced to a degree of fortune, assume them without a legal title.

The essential and integral parts of arms are these: 1. The escutcheon. 2. The tinctures. 3. The charges. 4. The ornaments.

Of the shield or escutcheon.—The shield or escutcheon is the field or ground whereon are represented the figures that make up a coat of arms: for these marks of distinction were put on bucklers or shields before they were placed on banners, standards, flags, and coat-armour; and wherever they may be fixed, they are still on a plane or superfices whose form resembles a shield.

Shields, in heraldry called escutcheons or scutcheons, from the Latin word scutum, have been, and still are, of different forms, according to different times and nations. Amongst ancient shields, some were almost like a horse-shoe, such as is represented by a few of the figures of escutcheons; others triangular, somewhat flat or rounded at the bottom. The English, French, Germans, and other nations, have their escutcheons formed different ways, according to the carver's or painter's fancy: of these various examples are contained in the plates of heraldry. But the shield of maids, widows, and of such as are born ladies, and are married to private gentlemen, is of the form of a lozenge (See Plate LXVI.)

Armorists distinguish several parts or points in escutcheons, in order to determine exactly the position of the bearings they are charged with; they are here denoted by the first nine letters of the alphabet, ranged in the following manner (See Plate LXV.)

The knowledge of these points is of great importance, and ought to be well observed, for they are frequently occupied with several things of different kinds. It is necessary to observe, that the dexter side of the escutcheon is opposite to the left hand, and the sinister side to the right hand of the person that look on it.

Distinction of houses. These distinctions inform us how the bearer of each is descended from the same family; they also denote the subordinate degrees in each house from the original ancestors, viz.

First house. For the heir or first son the label; second son the crescent; third son the mullet; fourth son the martlet; fifth son the annulet; sixth son the fleur-de-lis.

Second house. The crescent, with the label on it, for the first son of the second son. The crescent on the crescent for the second son of the second son of the first house, &c. See the Plate.

By the *tinctures* or colours is meant that variety of hue of arms common both to shields and their charges: the colours generally used are red, blue, sable, vert, purpure. Note, yellow and white, termed or and argent, are metals; these colours are represented in engravings by dots and lines, as in the Plate.

Or is expressed by dots.

Argent is plain.

Gules, by perpendicular lines.

Azure, by horizontal lines.

Sable, by perpendicular and horizontal lines crossing each other.

Vert, by diagonal lines from the dexter chief to the sinister base point.

Purpure, by diagonal lines from the sinister chief to the dexter base point.

Furs.—There are different kinds, and represent the hairy skins of certain animals, prepared for the linings of robes of state; and anciently shields were covered with furred skins: they are used in coats of arms, viz.

Ermine, is black spots on a white field.

Ermines, is a field black with white spots.

Erminois, is a field gold with black spots.

Vair, is white and blue, represented by figures of small escutcheons arranged in a line, so that the base argent is opposite to the base azure.

Potent-counter-potent, is a field covered with figures like crutch heads. See Plate.

Charges, are whatsoever bearings or figures are borne in the field of a coat of arms.

Rampant, signifies the lion standing erect on one of the hind legs.

Rampant-gardant, is a lion standing on his hind leg, looking full-faced.

Rampant-regardant, standing upon his hind leg, looking back towards his tail.

Passant: this term is to express the lion in a walking position.

Sejant, for the lion sitting, as the example.

Saliant, is when the lion is leaping or springing forward, as the example.

Couchant, is a lion lying at rest, with the head erect.

Passant-gardant, for a beast, when walking, with its head looking full-faced.

Couped, cut off smooth and even, as the example.

Erased, signifying torn or plucked off, as the example.

Demy, is the half of any charge, as the example, a demy lion.

Dormant, for sleeping with its head resting on its fore paws.

Partition lines, by which is understood a shield divided or cut through by a line or lines, either horizontal, perpendicular, diagonal, or transverse: the engraved examples are the crooked lines of partition, viz. engrailed, invecked, wavy, nebule, imbattled, raguly indented, dancette, dove tail. See Plate LXV.

Roundels are round figures, much used in arms: the English heralds vary their names according to their colour, thus:

Or,	is termed a	Bezant.
Argent,		Plate.
Gules,		Torteaux.
Azure,		Hurt.
Sable,		Pellett.
Vert,		Pomey.
Purpure,		Golpe.

Crescent, or half-moon, having its horns turned upwards.

Increscent, differs from the crescent, by having its horns turned to the dexter side.

Decrescent, is the reverse of the increscent, having its horns turned to the sinister side.

Rose, is represented, in heraldry, full-blown, with fine green barbs, and seeded in the middle.

Annulet, or ring, and by some authors supposed to be rings of mail.

Chess-rook. This piece is used in the game of chess.

Star, in heraldry, is termed an estoile, having six waved points.

Trefoil, or three-leaved grass.

Quartrefoil, or four-leaved grass.

Cinquefoil, or five-leaved grass.

Mascle, is in shape like the lozenge, but is always perforated, as the example.

Fountain, an heraldic term for a roundle barry wavy of six argents and azure.

Billet, a small parallelogram, supposed to be letters made up in the form of the example.

Rustre, is a lozenge pierced round in the middle.

Gutte, in heraldry, signifies drops of any thing liquid, and, according to their colour, are termed as follow: if

Or,	Gutte d'or.
Agent,	Gutte d'eau.
Vert,	Gutte de olive.
Gules,	Gutte de sang.
Azure,	Gutte de larmes.
Sable,	Gutte poix.

Fess, an ordinary composed of two horizontal lines drawn across the centre of the shield.

Chevron, an ordinary, in form like two rafters of a house, or a pair of compasses extended.

Bend, an ordinary, drawn diagonally from the dexter chief to the sinister base, and takes up one-third of the field.

Pale, an ordinary, which is placed perpendicular in the centre of the shield.

Chief, an ordinary, which always occupies the upper part of the shield, and contains in depth the third of the field.

Cross, an ordinary, composed of four lines, four perpendicular, and two transverse.

Saltire, an ordinary, in form like the cross of St. Andrew.

Bend-sinister, which is placed diagonally from the sinister chief to the dexter base of the shield.

Quarter, an ordinary, formed of two lines, one perpendicular, the other horizontal, taking up one-fourth of the field, as the example.

Canton, an ordinary in form like the quarter, but the size is only the third part of the chief.

Pile, an ordinary, like the foot of the pile that is driven into the ground to make the foundation of a building in swampy ground.

Flanches, are composed of two circular lines, and are always borne double, as the example.

Flory, a cross, the ends terminating in fleurs-de-lis.

Moline, a cross, which turns round both ways at the extremities, like a hook.

Pattee, a cross, small in the centre, and widening to the ends, which are very broad.

Croslet, a cross, crossed again at the extremities at a small distance from each of the ends.

Lozenge, a four-cornered figure, like a pane of glass in old casements, supposed to be a physical composition given for colds, and was invented to distinguish eminent physicians.

Mullet, consists of five points, and pierced in the centre, and is supposed to represent a spur rowel.

Mill-rind, a cross in form like the mill-ink which carries the millstone, and is perforated in the centre.

Water-boujet, anciently used as a vessel by soldiers for carrying water in long marches.

Helmets, were formerly worn as a defensive weapon to cover the bearer's head: a helmet is now placed over a coat of arms as its chief ornament, and a mark of gentility. The

First is a side-faced helmet of steel, with the vizor shut, for an esquire.

Second is a full-faced helmet of steel, with the vizor open, for knights or baronets.

Third is a side-faced helmet of steel, the bars and ornaments gold, for the nobility.

Fourth is a full-faced helmet, with bars all gold, for the sovereign and princes of the blood royal.

Close, signifies the wings of a bird are down, and close to the body.

Rising. This term is for a bird when in a position as if preparing to fly.

Displayed, signifies the wings of an eagle to be expanded, as the example.

Volant, a term for any bird represented flying.

Tripping, a term for a stag, antelope, or hind, when walking.

Courant, for a stag, or horse, or greyhound, running.

At gaze, is a term for a stag or hind; when looking full-faced, is termed at gaze.

Lodged, signifies the stag to be at rest on the ground.

Inverted, is for two wings conjoined, and the points of the wings downwards.

Erect, is for two wings conjoined, and the points erect, or upwards.

Hauriant. This term is for a fish when erect, paleways, as putting its head above water.

Naiant, for a fish, when borne horizontally across the shield, as swimming.

Cockatrice, a chimerical figure used in heraldry; its beak, wings, legs, comb, wattles, and spurs, partake of the fowl; and its body and tail of the snake.

Wyvern. This, like the former, is chimerical, and differs from the cockatrice in its head, having no comb, wattles, or spurs.

Dragon. This is an heraldic figure, as drawn by heralds. See the example.

Tiger. This, like the former, is of heraldic crea-

tion; being so different from the tiger of nature, it is termed the heraldic tiger.

Checky, is a shield or bearing, covered with small squares of different colours alternately.

Gyronny, is a shield divided into six or eight triangular parts of different colours, and the points all meeting in the centre of the shield.

Paly, is a shield divided into four, six, or more equal parts, by perpendicular lines, consisting of two colours.

Barry, is a shield divided into four, six, or more equal parts, by horizontal lines of two colours.

Bachelor.—The arms of a bachelor, whilst he remains such, he may quarter his paternal coat with other coats, if they belong to him, but he may not impale it till he is married.

Married man.—A married man is to conjoin the coat armours of himself and wife in one escutcheon paleways; the man's on the dexter side of the shield, and the woman's on the sinister side.

An heiress.—When an heiress is married, her arms are not to be impaled with her husband's, but are to be borne on an escutcheon of pretence, placed in the centre of the shield. Note, the escutcheon of pretence displays his pretension to her estate; and if the husband has issue by her, the heir of those two inheritors shall bear the hereditary coats of father and mother quarterly.

Quarterly.—Is an arms divided into four parts by a perpendicular and horizontal line crossing each other, in the centre of the shield, into four equal parts, termed quarters.

Maid.—The arms of a maid are to be placed in a lozenge; and if her father bore any difference in his coat the same is to be continued; for by the mark of cadency of her father's will be denoted what branch she is from.

Widow.—The arms of a widow are to be impaled with the arms of her late husband; her husband on the dexter side, and her's on the sinister side, upon a lozenge, as the example.

Knight of the garter and his lady.—When a knight of the garter is married, his wife's arms must be placed in a distinct shield, because his arms are surrounded with the ensign of that order: for though the husband may give his equal share of the shield and hereditary honour, yet he cannot share his temporary order of knighthood with her.

Commoner and his lady.—The arms of a commoner married to a lady of quality: he is not to impale her arms with his own; they are to be set aside of one another in separate shields, as the lady still retains her title and rank. See the example.

Of the external ornaments of escutcheons.—The ornaments that accompany or surround escutcheons denote the birth, dignity or office, of the person to whom the coat of arms appertaineth; and obtains both among the laity and clergy. The chief of which are as follow:

Crowns.—The first crowns were only diadems, bands, or fillets; afterwards they were composed of branches of divers trees, and then flowers were added to them. Among the Greeks, the crowns given to those who carried the prize at the Isthmian games, were of pine; at the Olympic, of laurel; and at the Nemean, of smallage. The Romans had various crowns to reward martial exploits and extraordinary services done to the republic. Examples of some of these crowns are frequently met with i modern achievements.

Modern crowns are only used as an ornament, which emperors, kings, and independent princes set on their heads, in great solemnities, to denote their sovereign authority. These are described in heraldry as follow:

The imperial crown is made of a circle of gold, adorned with precious stones and pearls, heightened with fleurs-de-lis, bordered and seeded with pearls, raised in the form of a cap voided at the top, like a crescent. From the middle of this cap rises an arched fillet enriched with pearls, and surmounted of a mound, whereon is a cross of pearls. See Plate LXVI.

The crown of the kings of Great Britain is a circle of gold, bordered with ermine, enriched with pearls and precious stones, and heightened up with four crosses pattee, and four large fleurs-de-lis alternately; from these rise four arched diadems adorned with pearls which close under a mound, surmounted of a cross like those at bottom.

The crowns of Spain and Portugal are a ducal coronet, heightened up with eight arched diadems that support a mound, ensigned with a plain cross. Those of Denmark and Sweden are both of the same form; and consist of eight arched diadems, rising from a marquis's coronet, which conjoin at the top under a mound ensigned with a cross botone. The crowns of most other kings in Europe are circles of gold, adorned with precious stones, and heightened up with large trefoils and closed by four, six, or eight diadems supporting a mound, surmounted of a cross.

The great Turk bears over his arms a turban, enriched with pearls and diamonds, under two coronets, the first of which is made of pyramidical points heightened up with large pearls, and the uppermost is surmounted with crescents.

The pope appropriates to himself a tiara or long cap of golden cloth: from which hang two pendants embroidered and fringed at the ends, semée of crosses of gold. This cap is inclosed by three marquis's coronets; and has on its top a mound of gold, whereon is a cross of the same, which cross is sometimes represented by engravers and painters pometted, recrossed, flowery, or plain. It is a difficult matter to ascertain the time when these haughty prelates assumed the three forementioned coronets. See Plate LXVI.

Coronets.—The coronet of the prince of Wales, or eldest son of the king of Great Britain, was anciently a circle of gold set round with four crosses-pattee, and as many fleurs-de-lis alternately; but since the restoration it has been closed with one arch only, adorned with pearls, and surmounted of a mound and cross, and bordered with ermine like the king's. But beside the coronet his royal highness has another distinguishing mark of honour, peculiar to himself, viz. a plume of three ostrich feathers, with an ancient coronet of a prince of Wales. Under it, in a scroll, is this motto, Ich dien, which in the German or old Saxon language signifies "I serve." The device was at first taken by Edward prince of Wales, commonly called the black prince, after the famous battle of Cressy, in 1346, where having with his own hand killed John, king of Bohemia, he took from his head such a plume, and put it on his own. See Plate LXV.

The coronet of all the immediate sons and brothers of the kings of Great Britain is a circle of gold, bordered with ermine, heightened up with four fleurs-de-lis, and as many crosses-pattee alternate. The particular and distinguishing form of such coronets as are appropriated to princes of the blood royal, is described and settled in a grant of Charles II. the 13th of his reign. See Plate LXV.

The coronet of the princesses of Great Britain is a circle of gold, bordered with ermine, and heightened up with crosses-pattee, fleurs-de-lis, and strawberry leaves alternate; whereas a prince's coronet has only fleurs-de-lis and crosses.

A duke's coronet is a circle of gold bordered with ermine, enriched with precious stones and pearls, and set round with eight large strawberry or parsley leaves. See Plate LXV.

A marquis's coronet is a circle of gold, bordered with ermine, set round with four strawberry leaves, and as many pearls on pyramidical points of equal height, alternately. See Plate LXV.

An earl's coronet is a circle of gold, bordered with ermine, heightened up with eight pyramidical points or rays, on the tops of which are as many large pearls, that are placed alternately with as many strawberry leaves, but the pearls much higher than the leaves. See Plate I.

A viscount's coronet differs from the preceding ones as being only a circle of gold bordered with ermine, with large pearls set close together on the rim, without any limited number, which is his prerogative above the baron, who is limited. See Plate LXV.

A baron's coronet, which it appears was granted by king Charles II., is formed with six pearls set at equal distances on a gold circle, bordered with ermine, four of which only are seen on engravings, paintings, &c. to show he is inferior to the viscount. See Plate LXV.

The eldest sons of peers, above the degree of a baron, bear their father's arms and supporters with a label, and use the coronet appertaining to their father's second title; and all the younger sons bear their arms with proper differences, but use no coronets.

As the crown of the king of Great Britain is not quite like that of other potentates, so do most of the coronets of foreign noblemen differ a little from those of the British nobility.

Mitres.—The archbishops and bishops of England and Ireland place a mitre over their coat of arms. It is a round cap pointed and cleft at the top, from which hang two pendants fringed at both ends; with this difference, that the bishop's mitre is only surrounded with a fillet of gold, set with precious stones, whereas the archbishops's issues out of a ducal coronet. See Plate LXV.

This ornament, with other ecclesiastical garments, is still worn by all the archbishops and bishops of the church of Rome, whenever they officiate with solemnity; but it is never used in England otherwise than on coats of arms, as before mentioned.

The first archbishop's consecration in England was in the year 568. No mitre but an archbishop's is borne upon a ducal coronet, except the bishop of Durham, that see being a principality.

The first bishop's consecration in England was in the year 516.

Chapeaux, wreaths, and crests.—A chapeau is an ancient hat, or rather cap, of dignity, worn by dukes, generally scarlet-coloured velvet on the outside, lined and turned up with fur; frequently to be met with above an helmet, instead of a wreath, under gentlemen's and noblemen's crests. Heretofore they were seldom to be found, as of right appertaining to primate families; but by the grants of Robert Cooke, Clarencieux, and other succeeding heralds, these, together with ducal coronets, are now frequently to be met with in families, who yet claim not above the degree of gentlemen. See Plate LXVI.

The wreath is a kind of roll made of two skains of silk of different colours twisted together, which ancient knights wore as a headdress when equipped for tournaments. The colours of the silk are always taken from the principal metal and colour contained in the coat of arms of the bearer. They are still accounted as one of the lesser ornaments of ecutcheons, and are placed between the helmet and the crest (see Plate LXVI). In the time of Henry I. and long after, no man who was under the degree of a knight had his crest set on a wreath; but this, like other prerogatives, has been infringed so far that every body now-a-days wears a wreath.

The crest is the highest part of the ornaments of a coat of arms. It is called crest, from the Latin word crista, which signifies comb or tuft, such as many birds have upon their heads, as the peacock, pheasant, &c. in allusion to the place on which it is fixed. See Plate LXVI. crest of the prince of Wales.

Crests were formerly great marks of honour, because they were only worn by heroes of great valour, or by such as were advanced to some superior military command, in order that they might be the better distinguished in an engagement, and thereby rally their men if dispersed; but they are at present considered as a mere ornament. The crest is frequently a part either of the supporters, or of the charge borne in the escutcheon. Thus the crest of the royal achievement of Great Britain is a "lion guardant crown'd." See Pl. LXVI. There are seral instances of crests that are relative to alliance, employments, or names; and which on that account have been changed.

The scroll and supporters.—The scroll is the ornament usually placed below the crest, containing a motto, or short sentence, alluding thereto, or to the bearings, or to the bearer's name, as in the two following instances. The motto of the noble earl of Cholmondeley is, "Cassis tutisima virtus;" *i. e.* "Virtue is the safest helmet;" on account of the helmet in the coat of arms. The motto of the right hon. lord Fortescue is, "Forte scutum salus ducum;" *i. e.* "A strong shield is the safety of the commanders;" alluding to the name of that ancient family. Sometimes it has reference to neither, but expresses something divine or heroic; as that of the earl of Scarborough, which is. "Murus æreus conscientia sana;" *i. e.* "A good conscience is a wall of brass." Others are enigmatical; as that of the royal achievement, which is, "Dieu et mon droit;" *i. e.* "God and my right;" introduced by Edward III. in 1340, when he assumed the arms and title of king of France, and began to prosecute his claim, which occasioned long and bloody wars, fatal, by turns, to both kingdoms. Mottos, though hereditary in the families that first took them up, have been changed on some particular occasions, and others

appropriated in their stead, instances of which are sometimes met with in the history of families.

Supporters are figures standing on a scroll, and placed at the side of the escutcheon; they are so called because they seem to support or hold up the shield. Supporters have formerly been taken from such animals or birds as are borne in the shields, and sometimes they have been chosen as bearing some allusion to the names of those whose arms they are made to support. The supporters of the arms of Great Britain, since king James the First's accession to the throne, are, a lion rampant guardant crowned or, on the dexter side, and an unicorn argent, crowned, armed, unguled, maned and gorged with an antique crown, to which a chain is affixed, all or, on the sinister. See Plate LXXI.

It is to be observed, that bearing coats of arms supported, is, according to the heraldic rules of England, the prerogative, 1st, Of those called nobiles majores, viz. dukes, marquisses, earls, viscounts, and barons; 2d, Of all knights of the garter, though they should be under the degree of barons; 3d, Of knights of the Bath, who both receive on their creation a grant of supporters; and, lastly, of such knights as the king chooses to bestow this honour upon.

Of the laws of heraldry, and the method of marshalling coats of arms.—1. The first and most general rule is, to express heraldic distinctions in proper terms, so as not to omit any thing that ought to be specified, and at the same time to be clear and concise without tautology. 2. Begin with the tincture of the field, and then proceed to the principal charges which possesses the most honourable place in the shield, such as fess, cheveron, &c. always naming that charge first which lies next and immediately upon the field. 3. After namning the tincture of the field, the honourable ordinaries, or other principal figures, you must specify their attributes, and afterwards their metal or colour. 4. When an honourable ordinary, or some one figure, is placed upon another, whether it be a fess, cheveron, cross, &c. it is always to be named after the ordinary or figure over which it is placed, with one of these expressions, surtout, or over all. 5. In the blazoning of such ordinaries as are plain, the bare mention of them is sufficient; but if an ordinary should be made of any of the crooked lines mentioned above, its form must be specified; that is, whether it be engrailed, wavy, &c. 6. When a principal figure possesses the centre of the field, its position is not to be expressed, or (which amounts to the same thing) when a bearing is named, without specifying the point where it is placed, then it is understood to possess the middle of the shield. 7. The number of the points of mullets or stars must be specified when more than five; and also if a mullet or any other charge be pierced, it must be mentioned as such, to distinguish it from what is plain. 8. When a ray of the sun, or other single figure, is borne in any other part of the escutcheon than the centre, the point it issues from must be named. 9. The natural colour of trees, plants, fruits, birds, &c. is no otherwise to be expressed in blazoning but by the word proper; but if discoloured, that is, if they differ from their natural colour, it must be particularized. 10. When three figures are in a field, and their position is not mentioned in the blazoning, they are always understood to be placed two above, and one below. 11. When there are many figures of the same species borne in a coat of arms, their number must be observed as they stand, and must be distinctly expressed.

By marshalling coats of arms is to be understood the art of disposing divers of them in one escutcheon, and of distributing their contingent ornaments in proper places. Various causes may occasion arms to be thus conjoined, which are comprised under two heads, viz. manifest and obscure. What is meant by manifest causes in the marshalling of coats of arms, are such as betoken marriages, or a sovereign's gift, granted either through the special favour of the prince, or for some eminent services. Concerning marriages it is to be observed,

1. when the coats of arms of a married couple, descended of distinct families, are to be put together in one escutcheon, the field of their respective arms is conjoined paleways, and blazoned parted per bale, baron and femme, two coats; first, &c. In which case the baron's arms are always to be placed on the dexter side, and the femme's arms on the sinister side.

2. If a widower marry again, his late and present wife's arms are, "to be placed on the sinister side, in the escutcheon with his own, and parted per pale. The first wife's coat shall stand on the chief, and the second on the base; or he may set them both in pale with his own, the first wife's coat next to himself, and his second outermost. If he should marry a third wife, then the two first matches shall stand on the chief, and the third shall have the whole base. And if he take a fourth wife, she must participate one-half of the base with the third wife, and so will they seem to be so many coats quartered." But it must be observed that these forms of impalring are meant of hereditary coats, whereby the husband stands in expectation of having the hereditary possession of his wife united to his patrimony. Note. If a man marry a widow, he marshals her maiden arms only.

3. In the arms of femmes joined to the paternal coat of the baron, the proper differences by which they were borne by the fathers of such women must be inserted.

4. If a coat of arms that has a bordure be impaled with another, as by marriage, then the bordure must be wholly omitted in the side of the arms next the centre.

5. The person that marries an heiress, instead of impailing his arms with those of his wife, is to bear them in an escutcheon placed in the centre of his shield, which, on account of its showing forth his pretension to her estate, is called an excutcheon of pretence, and is blazoned surtout, that is, over-all. But the children are to bear the hereditary coat of arms of their father and mother quarterly, which denotes a fixed inheritance, and so transmit them to posterity. The first and fourth quarters generally contain the father's arms, and the second and third the mother's; except the heirs should derive not only their estate, but also their title and dignity, from their mother.

6. If a maiden or dowager lady of quality marry a commoner, or a nobleman inferior to her in rank, their coats of arms may be set beside one another, in two separate escutcheons, upon one mantle or drapery, and the lady's arms ornamented according to her title. See Plate LXVI.

7. Archbishops and bishops impale their arms differently from the fore-mentioned coats, in giving the place of

honour, that is, the dexter side, to the arms of their dignity, as it is expressed in Plate LXV. which represents the coat of arms of a supposed archbishop of Canterbury and bishop of an English see.

With respect to such armorial ensigns as the sovereign thinks fit to augment a coat of arms with, they may be marshalled in various ways, as may be seen in the arms of his grace the duke of Rutland, and many others.

So far the causes for marshalling divers arms in one shield, &c. are manifest. As to such as are called obscure, that is, when coats of arms are marshalled in such a manner that no probable reason can be given why they are so conjoined, the explanation of them must be left to the heralds.

Of the orders of knighthood, &c.—The baronet's mark of distinction, or the arms of the province of Ulster in Ireland, granted and made hereditary in the male line by king James I. who erected this dignity on the 22d of May, 1611, in the 9th year of his reign, in order to propagate a plantation in the forementioned province. This mark is argent, a sinister hand couped at the wrist and erected gules; which may be borne either in a canton, or in an escutcheon, as will best suit the figures of the arms. The ancient and respectable badge of the most noble order of the garter, was instituted by king Edward III. 1349, in the 27th year of his reign. This honourable augmentation is a deep blue garter, surrounding the arms of such knights, and inscribed with this motto, "Honi soit qui mal y pense." See plate LXVI.

The arms of those who are knights of the orders of the Bath, of the Thistle, or of St. Patrick, are marshalled in the same manner, with this difference only, that the colour and motto accord with the order to which it belongs. Thus the motto, "Quis separabit 1783," on the light blue ribbon of the order, surrounds the escutcheon of a knight of St. Patrick. "Nemo me impune lacessit," on a green ribband, distinguishes a knight of the Thistle; and "Tria juncta in uno," on red, a knight of the Bath. It is to be observed that none of the orders of knighthood are hereditary. The honours of a baronet of Ulster, and of a baronet of Nova Scotia (created by patent in 1602), descend to the heirs male.

With regard to the emblazoning of the wife's arms in the case of the husband being noble; or where, on the other hand, the wife is noble in her own right, and the husband a commoner, these will be found exemplified in Plate LXVI.

For representations of the badges of the several orders of knighthood, see Plate LXVI. See ARMS, BLAZONING, PRECEDENCY, and the several terms of heraldry in alphabetical order.

HERBAL, is sometimes used for what is more usually called hortus siccus. See HORTUS SICCUS.

HERCULES, in astronomy, a constellation of the northern hemisphere, said to contain from 28 to 95 stars.

HEREDITAMENTS, all such things immoveable, whether corporeal or incorporeal, as a man may leave to his heirs, by way of inheritance; or not being otherwise devised, do naturally descend to him who is next heir of blood, and fall not within the compass of an executor or administrator, as chattles do. It is a word of large extent, and much used in conveyances; for by the grant of hereditaments, isles, seignories, manors, houses, and lands of all sorts, charters, rents, services, advowsons, commons, and whatever may be inherited, will pass. Co. Lit. 6.

Hereditaments are of two kinds, corporeal and incorporeal. Corporeal hereditaments consist wholly of substantial and permanent objects, all which may be comprehended under the general denomination of land only: for land comprehends in its legal signification any ground, soil, or earth whatsoever, as arable, meadows, pastures, woods, moors, waters, marshes, furzes, and heath. 1 Inst. 4.

Incorporeal hereditaments are not the objects of sensation, neither can they be seen or handled, are creatures of the mind, and exist only in contemplation: they are principally of ten sorts, viz. advowsons, tithes, commons, ways, offices, dignities, franchises, corodies or presents, and rents. Black.

HERESEY, among protestants, is said to be a false opinion, repugnant to some point of doctrine clearly revealed in scripture, and either absolutely essential to the christian faith, or at least of most high importance. 1 Haw. 3.

All old statutes that give a power to arrest or imprison persons for heresey, or introduced any forfeiture on that account, are repealed; yet by the common law an obstinate heretic being excommunicated is still liable to be imprisoned by force of the writ, de excommunicato capiendo, till he makes satisfaction to the church. 1 Haw. 5.

And if any person having been educated in, or having made profession of the christian religion within this realm, shall be convicted in any of the courts at Westminster, or at the assizes, of denying any of the persons in the Holy Trinity to be God, or maintaining that there are more gods than one, or of denying the truth of the christian religion, or the divine authority of the holy scriptures, he shall, for the first offence, be adjudged incapable of any office; and for the second shall be disabled to sue any action, or to be guardian, executor, or administrator, or take by any legacy or deed of gift, or to bear any office civil or military, or benefice ecclesiastical, for ever, and shall also suffer imprisonment for three years, without bail or mainprise, from the time of such conviction.

HERIOT, signifies a tribute given to the lord for his better preparation towards war. And by the laws of Canute it appears, that at the death of the great men of his nation so many horses and arms were to be paid for as they were in the their respective lifetimes obliged to keep for the king's service.

A heriot was first paid in arms and horses; it is now by custom sometimes the best live beast which the tenant dies possessed of; sometimes the best inanimate good, under which a jewel or piece of plate may be included. 2 Black. 422.

As to the several kinds of heriots, some are due by custom, some by tenure, and by reservation on deeds executed within time of memory; those due by custom are the most frequent, and arose by the contract or agreement of the lord and tenant, in consideration of some benefit or advantage accruing to the tenant, and for which an heriot, as the best beast, best piece of household fur-

niture, &c. became due, and belonged to the lord either on the death or alienation of the tenant, and which the lord may seize, either within the manor or without, at his election. Dyer, 199, b.

It has been solemnly adjudged that for an heriot service, or for an heriot reserved by way of tenure, the lord may either seize or distrain; for when the tenant agrees that the lord shall on his death have the best beast, &c. the lord has his election which beast he will take, and by seizing thereof reduces that to his possession, wherein he had a property at the death of the tenant, without the concurring act of any other person; and it is not like the case where the tenant receives 20*s.* or a robe, for there the lessee has his election which he will pay, and being to do the first act, the lord cannot seize, but must distrain. Plowd. 96.

If the tenure be by rent and heriot service, viz. to have the best beast after the death of the tenant, and the lord distrain for the heriot, he cannot in his avowry show which was the best beast that he was entitled to, nor of what value it was; for the tenant might have esloined the cattle, and thereby it might have been impossible for the lord to know which was the best beast; and the tenant at his peril is to render the best beast, or sufficient recompense. Cro. Car. 260.

Upon the whole, the custom of the manor is the law of it in all such like cases.

HERISSON, in fortification, a beam armed with a great number of iron spikes, with their points outwards, and supported by a pivot, on which it turns. These serve as a barrier to block up any passage, and are frequently placed before the gates, and more especially the wicket-doors of a town or fortress, to secure those passages which must of necessity be often opened and shut. See FORTIFICATION.

HERITIERA, a genus of the monœcia monadelphia class and order. The calyx is five-toothed; corolla none. Male, anthers 10, without filaments. Female, germ five; drupes with one globular seed. There is one species, a tree of the East Indies.

HERMÆA, in antiquity, ancient Greek festivals, in honour of the god Hermes, or Mercury.

HERMANNIA, a genus of the pentandria order, in the monadelphia class of plants, and in the natural method ranking under the 37th order, columniferæ. The capsule is quinquelocular; the petals at the base are semi-tubulated and oblique. There are 21 species, the most remarkable are,

1. The lavendulifolia, which has a shrubby stalk and slender branches, very bushy, about a foot and a half high, small, spear-shaped, obtuse, and hairy leaves, with clusters of small yellow flowers along the sides of the branches, continuing from June to autumn.

2. The althæifolia has a shrubby stalk, and soft woolly branches, growing two feet high, with numerous yellow flowers in loose spikes growing at the end of the branches, and making their appearance in July.

3. The grossularifolia has a shrubby stalk and spreading branches, growing three or four feet high, with bright yellow flowers coming out in great numbers at the ends of all the shoots and branches in April or May.

4. The alnifolia has a shrubby stalk, and branches gorwing irregularly four or five feet high, with pale yellow flowers in short spikes from the sides and ends of the branches, appearing in April or May.

5. The hyssopifolia has a shrubby upright stalk, branching out laterally six or seven feet high, with pale yellow flowers in clusters from the sides of the branches, appearing in May and June. All these plants are natives of Africa, and therefore must be kept in a greenhouse during the winter in this country. They are propagated by cuttings of their young shoots, which may be planted in pots of rich earth any time from April to July.

HERMAS, a genus of the monœcia order, in the polygamia class of plants. The umbel in the hermaphrodite is terminal; there is an universal involucrum, and partial ones. The rays of the small umbels are lobed; the central one flower-bearing; there are five petals, and as many barren stamina; the seeds are two-fold, and suborbicular. In the male the lateral umbels have universal and partial involucra; the small umbels are many-flowered; there are five petals, and five fertile stamina. There are five species, herbs of the Cape.

HERMETICAL SEAL, among chemists, a method of stopping glass-vessels, used in chemical operations, so closely, that the most subtile spirit cannot escape through them. It is commonly done by heating the neck of the vessel in a flame, till ready to melt, and then twisting it close together with a pair of pincers. Or, vessels may be hermetically sealed, by stopping them with a glass plug, well luted; or by covering the vessel with another ovum philosophicum.

HERNANDIA, *jack-in-a-box-tree,* a genus of the triandria order, belonging to the monœcia class of plants, and in the natural method ranking under the 38th order, tricoccæ. The male calyx is tripartite; the corolla tripetalous; the female calyx is truncated, quite entire; the corolla hexapetalous; the plum hollow, and open at the mouth or upper part, with a loose kernel. The species are,

1. The sonora, or common jack-in-a-box, a native of both the Indies. It grows 20 or 30 feet high, with broad peltated leaves, and monœcious flowers, succeeded by a large swoollen hollow fruit formed of the calyx; having a hole or opening at the end, and a hard nut within. The wind blowing into the cavity of this fruit makes a very whistling and rattling noise, whence comes the name.

2. The ovigera grows many feet high, with large oval leaves not peltated; and monœcious flowers, succeeded by a swoollen fruit open at the end, and a nut within. It is said the sonora in Java affords a sure antidote against poison, if you either put its small roots on the wounds, or eat them; as was discovered to Rumphus by a captive woman in the war between the people of Macassar and the Dutch, in the year 1667. The soldiers of the former always carry this root about them, as a remedy against wounds with poisoned arrows. Both these plants being tender exotics, must be planted in pots of rich earth, and always kept in a hot-house; in which, notwithstanding all the care that can be taken, they seldom flower, and never grow beyond the height of common shrubs, though in the places where they are natives they arrive at the height of trees. They are propagated by seeds procured from the West Indies.

HERNIA. See MEDICINE and SURGERY.

HERNIARIA, *rupture-wort*, a genus of the digynia order, in the pentandria class of plants, and in the natural method ranking under the eleventh order, holoraceæ. The calyx is quinquepartite; there is no corolla; there are five barren stamina, and a monospermous capsule. There are four species, of which the only remarkable one is the glabra, or smooth rupture-wort, a native of many parts of England. It is a low trailing plant, with leaves like the smaller chickweed; the flowers come out in clusters from the side of the stalks at the joints, and are of a yellowish green colour. This plant is a little saltish and astringent. The juice is useful to take away specks in the eye. Cows, sheep, and horses, eat the plant; goats and swine refuse it.

HERON, in ornithology. See Ardea.

HERRING, in ichthyology. See Clupea and Fishery.

HERRINGS. It is unlawful to buy or sell herrings at sea before the fishermen come into the haven, and the cable of the ship be drawn to the land. 31 Ed. III. c. 2.

No herring shall be sold in any vessel but where the barrel contains 32 gallons, and half barrel and firkin accordingly; and they must be well packed, of one time's packing and salting, and be as good in the middle as at the ends; on pain of forfeiting 3*s.* 4*d.* a barrel.

Vessels with herrings are to be marked with the quantity and place where packed; and packers are to be appointed and sworn in all fishing ports, and under the penalty of 100*l.*

HERSE, in fortification, is a lattice or portcullice, made in the form of a harrow, and stuck full of iron spikes. See Fortification.

HESPERIS, *dame's violet*, or *queen's gilliflower*, a genus of the siliquosa order, in the tetradynamia class of plants, and in the natural method ranking under the 39th order, siliquosæ. The petals are turned obliquely; there is a glandule within the shorter stamina; the siliqua almost upright; the stigma forked at the base, connivent, or closing at the top. There are seven species, the most remarkable are,

1. The matronalis, or common sweet-scented garden rocket, having fibrous roots, crowned with a tuft of long, spear-shaped, rough, leaves; upright, single, hairy stalks, two feet high, terminated by large and long spikes of sweet-scented flowers of different colours and properties in the varieties, of which there is a great number. All the varieties of this species are so remarkable for imparting a fragrant odour, that the ladies were fond of having them in their apartments. Hence they derived the name of dame's violet; and bearing some resemblance to a stock-gilliflower were sometimes called queen's gilliflower, but are now most commonly called rocket.

2. The inodora, or scentless rocket, has upright stalks two feet high, all the branches terminated by large spikes of scentless flowers, with obtuse petals, of different colours and properties in the varieties.

3. The tristis, or dull-flowered night-smelling rocket, has upright, bristly stalks, two feet high, spear-shaped pointed leaves, and spikes of pale purple flowers, of great fragrance in the evening.

All the species are hardy, especially the first and second, which prosper in any of the open borders, and any common garden soil; but the third, being rather impatient of a severe frost, and of much moisture in winter, should have a dry warm situation, and a few may be placed in pots, to be sheltered in case of inclement weather. They may be propagated either by seeds, by offsets, or by cuttings off the stalks.

HESSIAN Fly. See Tenthredo.

HETEROGENEOUS Numbers, mixed numbers, consisting of integers and fractions.

Heterogeneous Quantities, are those which are of such different kinds, as that one of them taken any number of times, never equals or exceeds the other.

Heterogeneous Surds, are such as have different radical signs, as $\sqrt[2]{aa}$, $\sqrt[5]{bb}$, $\sqrt[3]{9}$, $\sqrt[7]{18}$, &c. See Surd.

If the indices of the powers of the heterogeneous surds be divided by their greatest common divisor, and the quotients be set under the dividends; and those indices be multiplied crosswise by each others quotients; and before the products be set the common radical sign $\sqrt{}$, with its proper index; and if the powers of the given roots be involved alternately, according to the index of each others quotient, and the common radical sign be prefixed before those products, then will those two surds be reduced to others, having but one common radical sign. As to reduce

$$\sqrt[2]{aa} \text{ and } \sqrt[4]{bb}$$
$$2)\sqrt{aa}\ (2 \quad \sqrt[4]{bb} \quad \begin{matrix} 1 \times 2 \\ \sqrt[4]{bb} \end{matrix} \quad \sqrt[4]{aaaa}$$

HETEROSCII. See Geography.

HETEROUSIANS, a sect of Arians, who did not believe that the Son of God was of a substance like to that of the Father.

HEUCHERA, in botany, a genus of the pentandria digynia class of plants, the corolla whereof consists of five petals; the fruit is an ovato-accuminated capsule; semibifid, terminating in two refex points, and containing two cells. There are two species.

HEXACHORD, in ancient music, a concord called by the moderns a sixth.

HEXAEDRON, or Hexahedron, one of the five regular or Platonic bodies; being indeed the same as the cube; and is so called from its having six faces—The square of the side or edge of a hexahedron, is one-third of the square of the diameter of the circumscribing sphere; and hence the diameter of a sphere is to the side of its inscribed hexahedron, as $\sqrt{3}$ to 1.

In general, if A, B, and C, be put to denote respectively the linear side, the surface and the solidity of a Hexahedron, or cube, also, the radius of the inscribed sphere, and R the radius of the circumscribed one; then we have these general equations or relations:

1. $A = 2r = \frac{2}{3}R\sqrt{3} = \sqrt{\frac{1}{6}B} = \sqrt[3]{C}$.
2. $B = 24\sqrt{} = 8R^2 = 6A^2 = 6\sqrt[3]{r^2}C^2$.
3. $C = 8r^3 = \frac{8}{9}R^3\sqrt{3} = A^3 = \frac{1}{6}B\sqrt{\frac{1}{6}B}$.
4. $R = r\sqrt{3} = \frac{1}{2}A\sqrt{3} = \frac{1}{2}\sqrt{\frac{1}{2}B} = \frac{1}{2}\sqrt{3} \times \sqrt[3]{C}$.
5. $r = \frac{1}{2}R\sqrt{3} = \frac{1}{2}A = \frac{1}{2}\sqrt{\frac{1}{6}B} = \frac{1}{2}\sqrt[3]{C}$.

HEXAGON, in geometry, a figure of six sides and angles; and if these sides and angles be equal, it is called a regular hexagon.

The side of every regular hexagon, inscribed in a circle, is equal in length to the radius of that circle. Hence, it is easy, by laying off the radius six times upon the circumference, to inscribe an hexagon in a circle.

To describe a regular hexagon on a given right line AB, (plate LXXII. Miscel. fig. 123,) draw an equilateral triangle ACB, and the vertex C will be the centre of a circle which will circumscribe the hexagon required ABDEFG.

As 1 is to 1 672, so is the square of the side of any regular hexagon to the area thereof, nearly. Or the side of a hexadon being s, its area will be $= 2.598076 2s^2 = \frac{3}{2}s^2 \times \text{tang. } 60^{\circ} = \frac{3}{2}s^2\sqrt{3}$.

HEXAGON, in fortification, is a place defended by six bastions.

HEXAMETER, in ancient poetry, a kind of verse, consisting of six feet; the first four of which may be indifferently, either spondees or dactyls; the fifth is generally a dactyl and the sixth always a spondee. Such is the following verse of Horace:

1 2 3 4 5 6

Aut pro | desse vo | lunt, aut | delec | tura po | etæ.

HEXANDRIA, in botany, a class of plants, the sixth in order, comprehending all those plants which have hermaphrodite flowers, and six stamina in each.

HIBISCUS. *Syrian mallow*, a genus of the polyandria order, in the monadelphia class of plants, and in the natural method ranking under the 37th order, columniferæ. The calyx is double, the exterior one polyphyllous, the capsule quinquelocular and polyspermous. Of this genus there are 45 species; the most remarkable of which are,

1. The Syriacus, commonly called althæa frutex.

2. The rosa sinensis, with an arborescent stem, and egg-pointed as wed leaves. It is a native of the East Indies, whence it has obtained the name of China rose; but the seeds having been carried by the French to their West India settlements, it has thence obtained the name of Martinico rose. Of this there are the double and single flowering kinds; the seeds of the first frequently produce plants that have only single flowers, but the latter seldom vary to the double kind.

3. The mutabilis, or changeable rose, has a soft spongy stem, which by age becomes ligneous and pithy. It rises to the height of 12 or 14 feet, with heart-shaped leaves. The flowers are produced from the wings of the leaves; the single are composed of five petals, which spread open, and are at first white, but afterwards change to a bluish rose-colour, and as they decay turn purple. In the West Indies all these alterations happen on the same day, and the flowers themselves are of no longer duration; but in Britain the changes are not so sudden.

4. The abelmoschus, or musk-seeded hibiscus, is a native of the West Indies, where the French cultivate great quantities of it. The stalks and leaves of this sort are very hairy. The flowers are large, of a sulphur colour, with purple bottoms; and are succeeded by pyramidal five-corned capsules, which open in five cells, filled with large kidney shaped seeds of a very musky odour.

5. The tiliaceus, or maho-tree, is a native of both the Indies. It rises with a woody, pithy stem, to the height of ten feet, with heart-shaped leaves ending in acute points. The flowers are produced in loose spikes at the end of the branches, and are of a whitish-yellow colour.

6. The trionum, Venice mallow, or flower of an hour, is a native of some parts of Italy, and has long been cultivated in the gardens of this country under the name of bladder ketmia.

7. The esculentus, or eatable hibiscus, rises to five or six feet; has broad five-parted leaves, and large yellow flowers. The pod or okra is from two to six inches long, and one inch diameter. When ripe it opens longitudinally in five different places, and discharges a number of heart-shaped seeds. "These (Dr. Wright informs us) are gathered green, cut into pieces, dried, and sent home as presents, or are boiled in broths or soups for food. It is the chief ingredient in the celebrated pepper-pot of the West Indies, which is no other than a rich olla: the other articles are either flesh meat, or dried fish and capsicum. This dish is very palatable and nourishing. As a medicine, okra is employed in all cases where emollients and lubricants are indicated."

HICKUP, or *hiccough*. See MEDICINE.

HIDE OF LAND, was such a quantity of land as might be ploughed with one plough within the compass of a year, or so much as would maintain a family; some call it 60, some 80, and some 100 acres.

HIERACITES, in church history, christian heretics in the third century, so called from their leader Hierax, a philosopher of Egypt; who taught that Melchisedic was the Holy Ghost, denied the resurrection, and condemned marriage, &c.

HIERACIUM, *hawkweed*, a genus of the polygamia æqualis order, in the syngenesia class of plants, and in the natural method ranking under the 49th order, compositæ. The receptacle is naked, the calyx is imbricated and ovate; the pappus simple and sessile. There are 55 species, of which the most remarkable are,

1. The aurantiacum, commonly called grim the collier, with an upright, single, hairy, and almost leafless stalk, a foot high, terminated by reddish orange-coloured flowers in a corymbus. These flowers have dark oval ash-coloured calyces; whence the name of grim the collier.

2. The pilosella, or mouse-ear, has blossoms red on the outside, and pale-yellow within; the cups set thick with black hairs. The flowers open at eight in the morning, and close about two in the afternoon.

3. The umbellatum grows to the height of three feet, with an erect and firm stalk, terminated with an umbel of yellow flowers.

HIEROGLYPHICS, in antiquity, mystical characters, or symbols, in use among the Egyptians, and that as well in their writings as inscriptions; being the figures of various animals, the parts of human bodies, and mechanical instruments.

The meaning of a few of these hieroglyphics has been preserved by ancient writers. Thus we are told they represented the supreme Deity by a serpent with the head of a hawk. The hawk itself was the hieroglyphic of Osris; the river-horse, of Typhon; the dog, of Mercury; the cat, of the moon, or Diana; the beetle, of a courageous warrior; a new-born child, of the rising sun; and the like.

HIEROGRAMMATISTS, holy registers, were an order of priests among the ancient Egyptians, who presided over learning and religion.

HIGH, in music, an epithet given to any tone or note considerably acute in respect of some other. A word arbitrarily used, and of various meanings, as applied to bass, tenor, or treble voices, or instruments.

HIGHWAY, a public passage for the king's people, whence it is called the king's highway. It seems that anciently there were but four highways in England, which were free and common to all the king's subjects, and through which they might pass without any toll, unless there were a particular consideration for it; all others which we have at this day are supposed to have been made through the grounds of private persons, on writs of ad quod dammum, &c. which being an injury to the owner of the soil, it is said they may prescribe for toll, without any special consideration. 3 Bac. Abr. 54.

There are three kinds of ways, a foot-way, a pack and prime way, which is both a horse and foot-way, and a cart-way, which contains the other two. 1 Inst. 56.

But notwithstanding these distinctions, it seems that any of the said ways, which is common to all the king's subjects, whether it leads directly to a market-town, or only from town to town, may properly be called an highway; and that any such cart-way may be called the king's highway; that a river common to all men may also be called an highway; and that nuisances in any of the said ways are punishable by indictment; otherwise they would not be punished at all: for they are not actionable, unless they cause a special damage to some particular person; because if such action would lie a multiplicity of suits would ensue. 2 Durnf. and East.

But it seems that a way to a parish-church, or to the common field of a town, or to a village which terminates there, may be called a private way, because it belongs not to all the king's subjects, but only to the particular inhabitants of such parish, house, or village, each of which, as it seems, may have an action for a nuisance therein. 1 Haw. 201.

If passengers have used time out of mind, where the roads are bad, to go by outlets on the land adjoining to an highway in the open field, such outlets are parcel of the highway; and therefore if they are sown with corn, and the track foundrous, the king's subjects may go upon the corn. 1 Roll. Ab. 300.

If a way which a man has becomes impassable or very bad, by the owner of the land tearing it up with his carts, by which means it is filled with water; yet he who has the way cannot dig the ground to let out the water, for he has no interest in the soil. But he may bring his action against the owner of the land for spoiling the way. Godb. 52.

When a private way is spoiled by those who have a right to pass thereon, and not through the default of the owner of the land, it seems that they who have the use and benefit of the way ought to repair it, and not the owner of the soil, unless he is bound thereto by custom or special government. 2 Burn. 483.

Repairing highways. It seems agreed that by the common law the general charge of repairing all highways lies on the occupiers of the lands in the parish wherein they are. But it is said that the tenants of the lands adjoining are bound to scour their ditches. 1 Roll. Abr. 39.

Particular persons may be burdened with the general charge of repairing an highway, in two cases: in respect of an inclosure, or by prescription. As where the owner of lands not inclosed, next adjoining to the highway, incloses his lands on both sides thereof; in which case he is bound to make a perfect good way, and shall not be excused for making it as good as it was at the time of the inclosure, if it was then any way defective; because before the inclosure, when the way was bad, the people for their better passage, went over the fields adjoining, out of the common track, a liberty which the inclosure has deprived them of.

And particular persons may be bound to repair an highway by prescription; and it is said that a corporation aggregate may be compelled to do it by force of a general prescription, that it ought and has used to do it, without showing that it used to do so in respect of the tenure of certain lands, or for other consideration; because such a corporation, in judgment of law, never dies, and therefore if it was ever bound to such duty, it must continue to be always so: neither is it any plea that such a corporation has always done it out of charity; for what it has always done, it shall be presumed to have been always bound to do. But it is said that such a general prescription is not sufficient to charge a private person, because no man is bound to do a thing which his ancestors have done, unless it is for some special reason; as having lands descended to him holden by such services, &c. 1 Haw. 202, 203.

It seems certain in all cases whether a private person is bound to repair an highway by inclosure or prescription, that the parish cannot take the advantage of it on the general issue, but must plead it specially; and that, therefore, if to an indictment against the parish for not repairing an highway, they plead not guilty, this shall be intended only that the ways are in repair, but does not go to the right of reparation. 1 Mod. 112.

At common law, it is said that all the county ought to make good the reparations of an highway, where no particular persons are bound to do it, because the whole county have their ease and passage by the said way. Co. Rep. 13.

By the ancient common law villages are to repair their highways, and may be punished for their decay; and if any does injury, or straightens the highway, he is punishable in the king's bench, or before the justices of peace in the court leet, &c. Cromp. Jurisd. 76.

Destroying any public turnpike-gate, or the rails, or fences thereto belonging, subjects the offender to hard labour for three months, and to be publicly whipped. 1 Geo. II. c. 19.

On conviction at the assizes, the offender may be transported for seven years. And on a second offence, or on demolishing any turnpike-house, he shall be guilty of felony, and transported for seven years. But in both these cases the prosecution must be within six months; and on the convict's returning from transportation he shall suffer death. 5 G. II. c. 33.

Every justice of the peace by the statute, upon his own view, or on oath made to him by the surveyor, may make presentment of roads being out of repair; and there

upon like processes shall be issued as upon indictment.

HIGHWAYMEN, are robbers on the highway; for the apprehending and taking of whom a reward of 40*l.* is given by the statute of 4 and 5 Will. and Mar.

HILLIA, a genus of the monogynia order, in the hexandria class of plants, and in the natural method ranking with those of which the order is doubtful. The calyx is hexaphyllous; the corolla cleft in six parts, and very long; the berry inferior, bilocular, and polyspermous. There are two species, shrubs of Jamaica.

HIP, or HAW, in the materia medica, is reputed attenuant and diuretic. There is a very pleasant conserve of hips kept in the shops.

HIPPIA, a genus of the polygamia necessaria order, in the syngenesia class of plants. The receptacle is naked; there is no pappus; the seeds are naked, with very broad margins; the calyx is hemispheric, and sub-imbricated; the radios consists of 10 corollulæ, obscure, and rather cleft into three. There are three species, shrubs of the East Indies and the Cape.

HIPPOBOSCA, a genus of insects of the order diptera. The generic character is, mouth furnished with a bivalve, cylindric, obtuse, nutant snout; body depressed; feet furnished with several claws. This is not an extensive genus; the European hippoboscæ, so far as our present entomological information reaches, scarcely affording more than five or six distinct species. Of these the most familiar is the hippobosca equina (see Plate LXVI. Nat. Hist. fig. 225), or horse-fly, so troublesome to those animals, as well as to cattle, during the decline of summer, by its irritating motion (which is performed in various directions with equal facility), and by the pungent pain which its proboscis excites while in the act of suction. In size it varies in different districts, and seems to be largest in the southern climates. It usually, however, measures something more than a quarter of an inch in length, and is of a flattened form, with a rounded abdomen, and moderately broad obtuse wings: its colour is a blackish chesnut, with the thorax speckled with white, and the abdomen marked with obscure variegations of a deeper cast: the skin is of a remarkably strong, or coriaceous nature, since the insect may be pressed strongly between the fingers without being apparently injured. The female of this insect deposits a single egg at distant intervals, and so very large is the egg, as at least to equal, if not in some degree to surpass, the size of the abdomen itself of the parent insect. In reality, however, this seeming egg may be rather considered as a pupa, since it undergoes no farther alteration of form. It continues perfectly inert, and gradually becomes of a brown, and at length of a polished, black colour; and thus commences a genuine or confirmed pupa, which, if opened after a certain period, exhibits the fly in its unadvanced state, and of a white colour. It often lies during the whole winter in this state, the fly emerging in the succeeding summer.

2. Hippobosca avicularia much resembles the preceding species; but is considerably smaller, and of a dull-green colour: it is often observed on the bodies of various birds, which it infests in a very troublesome degree.

3. Hippobosca hirundinis is equal in size to the H. avicularia, and is of a livid-greenish colour, with the abdomen deeply emarginated behind, so as to represent the usual figure of an inverted heart: the wings are of a sharpened or lanceolate form; and the feet, instead of being terminated by two claws only, as in the generality of insects, have six sharp curved divisions. This species is very often observed on the bodies of swallows, swifts, and martins; and may almost always be found in their nests. Its motion, like that of the two preceding kinds, is brisk, but irregular, moving in all directions with equal facility. The egg or pupa of this species is at least as large in proportion to the parent as that of the horse-fly: it gradually changes to a jet-black colour, and the complete fly is usually produced from it in the space of a month.

4. Hippobosca ovina is commonly known by the name of the sheep-tick, and is very frequently found imbedded in the wool of those animals. It is of a reddish-brown colour, and differs from the rest of the genus in being entirely destitute of wings. Its pupa is also a reddish-brown colour, exactly oval, and of a shining surface.

All the hippoboscæ are remarkably tenacious of life, and the H. ovina in particular, which may often be observed in wool that has long been packed into fleeces.

HIPPOCRAMPUS. See SYNGNETHUS.

HIPPOCRATIA, a genus of the monogynia order, in the triandria class of plants, and in the natural meth o ranking with those of which the order is doubtful. The calyx is quinquepartite; the petals five, the capsules three in number, and the latter of an obcordate shape. There are two species, scandent plants of the West Indies.

HIPPOCREPIS, *common horse-shoe-vetch*, a genus of the decandria order, in the diadelphia class of plants, and in the natural method ranking under the 32d order, papilionaceæ. The legumen is compressed and crooked, with many incisions on the interior suture. There are five species, two natives of the warm parts of Europe, and one of Britain. They are all low herbaceous trailing plants, with yellow flowers. They are propagated by seeds; but having no great beauty are seldom kept in gardens.

HIPPOMANE, the *manchineel-tree*, a genus of the monadelphia order, in the monœcia class of plants, and in the natural method ranking under the 38th order, tricoccæ. The male has an amentum and bifid perianthium, without any corolla; the female perianthium is trifid; there is no corolla; the stigma is tripartite; and the plum or capsule tricoccous. See Plate. The species are,

1. The mancinella, with oval sawed leaves, is a native of all the West Indie islands. It has a smooth brownish bark. The flowers come out in short spikes at the end of the branches, but make no great appearance, and are succeeded by fruit of the same shape and size with a golden pippin. The tree grows to the size of a large oak.

2. The biglandulosa, with oblong bay leaves, is a native of South America; and grows to as large a size as the first, from which it differs mostly in the shape of its leaves.

3. The spinosa, with holly leaves, is a native of Campeachy, and seldom rises above 20 feet high; the leaves greatly resemble those of the common holly, and

are set with sharp prickles at the end of each indenture. They are of a lucid green, and continue all the year.

These plants being natives of very warm climates cannot be preserved in this country without a stove; nor can they by any means be made to rise above five or six feet high even with that assistance. They are propagated by seeds; but must have very little moisture, or they will certainly be killed by it.

These trees have a very poisonous quality, abounding with an acrid milky juice of a highly caustic nature. Strangers are often tempted to eat the fruit of the first species; the consequences of which are, an inflammation of the mouth and throat, pains in the stomach, &c. which are very dangerous, unless remedies are speedly applied. The wood is much esteemed for making cabinets, book-cases, &c. being very durable, taking a fine polish, and not being liable to become worm-eaten: but as the trees abound with a milky caustic juice already mentioned, fires are made round their trunks to burn out this juice, otherwise those who fell these trees would be in danger of losing their sight by the juice flying in their eyes. This juice raises blisters on the skin wherever it fails, turns linen black, and makes it fall out in holes. It is also dangerous to work the wood after it is sawn out; for if any of the sawdust happens to get into the eyes of the workmen it causes inflammation; to prevent which they generally cover their faces with fine lawn during the time of working the wood. It is with the juice of this tree that the Indians used to poison their arrows.

HIPPOPHAE, *sea-buckthorn*, a genus of the tetrandria order, in the diœcia class of plants, and in the natural method ranking under the 16th order, calycifloræ. The male calyx is bipartite; there is no corolla; the female calyx is blind; there is no corolla; there is one style, and a monospermous berry. The species are,

1. The rhamnoides, with a shrubby stem. branching irregularly eight or ten feet high, having a dark-brown back.

2. The canadensis has a shrubby brown stem, branching eight or ten feet high, with oval leaves, and male and female flowers on different plants. Both these species are very hardy, and may be propagated in abundance by suckers from the roots, by layers, and by cuttings of their young shoots. They are retained in gardens on account of their two-coloured leaves in summer; and in winter on account of the appearance of the young shoots, which are covered with turgid, irregular, scaly-buds. Goats, sheep, and horses, eat the first species; cows refuse it.

HIPPOPOTAMUS, a genus of quadrupeds of the order of belluæ. The generic character is, the front teeth of the upper jaw are four, and placed in pairs; those of the lower jaw are prominent, and the intermediate ones are protruded forward; the canine teeth are single, and obliquely truncated; the teats are only two, and placed near the groin. It is a native of the warmer regions of the globe, and is chiefly found in the middle parts of Africa, inhabiting large rivers, and especially such as run through countries overshadowed by large forests; walking about at the bottom, and raising itself at intervals to the surface, for the purpose of respiration. By night it quits its watery residence, to graze in the neighbouring plains, devouring great quantities of herbage, and with its vast teeth destroying the more tender kinds of trees and other vegetables. It is sometimes seen even in the sea, at some distance from the mouths of rivers, but this is supposed to be merely for the purpose of exercise; for it will not even drink salt water, and does not prey on fish, or indeed live on any kind of animal food. The general size of the hippopotamus seems to be nearly equal to that of the rhinoceros, and it is sometimes even superior. Its form is highly uncouth; the body being extremely large, fat, and round; the legs very short and thick; the head very large; the mouth extremely wide, and the teeth of vast strength and size, more particularly the tusks or canine teeth of the lower jaw, which are of a curved form: they sometimes measure more than two feet in length, and weigh upwards of six pounds each. The whole animal is covered with short hair, which is much more thinly set on the under parts than on the upper. The hippopotamus when just emerged from the water appears of a palish-brown, or mouse colour, with a blueish or slate coloured cast, on the upper parts; and the belly is flesh coloured, the skin appearing through the hair. When perfectly dry the colour is an obscure brown, without any of the blueish cast. The skin is most excessively tough and strong, except on the belly, where it is considerably softer. Its voice is a peculiar kind of interrupted roar, between that of a bull and the braying of an elephant. When on land it moves in a somewhat slow and awkward manner; but if pursued, can run with considerable speed, and directly plunging into the water sinks to the bottom, and pursues its progress beneath. It is observed to be extremely cautious of making its appearance by day, especially in such places as are much frequented by mankind, scarcely lifting its nose above the surface while breathing; but it is fearless in rivers which run through unfrequented regions, where it is occasionally seen to rush out of the water with sudden impetuosity, trampling down every thing in its way; and at such time is, of course, highly dangerous. It is, however, naturally of a harmless disposition; not attacking other animals; but merely committing havoc in plantations of maize, rice, sugar-canes, &c. and destroying the roots of trees, by loosening them with its vast teeth. It is capable, notwithstanding its great bulk, of swimming very swiftly. Sometimes hippopotami are seen going in herds, or companies, to the distance of some miles from the bank of a river in quest of food. If wounded in the water they become furious, and are said to attack the boats or canoes whence the injury proceeded, and either overturn or sink them, by biting out large pieces from the bottom. The hippopotamus sleeps in the small reedy islets which are found here and there in the rivers it frequents. In such spots it also brings forth its young; having only one at a birth, which it nurses with great care for a considerable time. The young is capable of being tamed, and we are assured by Belon that he saw one so gentle as to show no inclination to escape, or to do any kind of mischief when let out of the stable in which it was kept.

These animals are said to be most successfully taken by preparing pitfals for them, of large size, near the rivers. They are also occasionally shot, or killed with harpoons. Their flesh is reckoned good by the Africans, and the fat is said to be a fine kind of lard. But it is

chiefly on account of the teeth, and more particularly of the tusks, that this animal is killed; their hardness being superior to that of ivory, at the same time that they are not so subject to become yellow, for which reason they are much used by the dentists. The skin, from its great thickness and strength, when dried, is used by the African nations for bucklers or shields, and is said to be proof against the stroke of a bullet; and indeed the living animal, if shot at any where but on the head or the belly, is scarcely vulnerable, the tough skin causing a bullet to glance from its surface.

The largest female hippopotamus killed by colonel Gordon was about 11 feet long, and the largest male, which always exceeds the female size, about 11 feet 8 inches. Mr. Bruce, however, speaks of hippopotami in the lake Tzana of more than twenty feet long.

The hippopotamus has only a single stomach, and does not ruminate: the stomach, however, has certain cells and divisions, analogous, in some degree, to those of the camel.

M. Sonnini thinks it not improbable that there may in reality exist two species of hippopotamus; one of which confines itself entirely to rivers and fresh waters, and the other to the sea. See Plate LXVII. Nat. Hist. fig. 226.

HIPPURIS, *mare's tail*, a genus of the monogynia order, in the monandria class of plants, and in the natural method ranking under the 15th order, inundatæ. There is no calyx, nor any petals; the stigma is simple; and there is one seed. There are three species, one a native of Britain, and which grows in ditches and stagnant waters. The flower of this plant is found at the base of each leaf, and is as simple as can be conceived; there being neither empalement nor blossom; and only one chive, one pointal, and one seed. It is a very weak astringent. Goats eat it; cows, sheep, horses, and swine, refuse it.

HIRÆA, a genus of the trigynia order, in the decandria class of plants. The calyx is pentaphyllous; the petals roundish and ungniculated; there are three bilabiated seeds. There is one species, a tree of New Spain.

HIRCUS, a goat, in astronomy, a star of the first magnitude, the same with capella. See CAPELLA and ASTRONOMY.

HIRTELLA, a genus of the monogynia order, in the pentandria class of plants, and in the natural method ranking with those of which the order is doubtful. There are five petals; the filaments are very long, persisting, and spiral; the berry is monospermous; the style lateral. There are three species, trees of the West Indies.

HIRUDO, the *leech*, a genus of insects belonging to the order of vermes intestina. The body moves either forward or backward. There are 17 species, principally distinguished by their colour. The most remarkable are the following:

1. The medicinalis, or medicinal leech, the form of which is well known, grows to the length of two or three inches. The body is of a blackish-brown colour, marked on the back with six yellow spots, and edged with a yellow line on each side; but both the spots and the lines grow faint, and almost disappear, at some seasons. The head is smaller than the tail, which fixes itself very firmly to any thing the creature pleases. It is viviparous, and produces but one young at a time, which is in the month of July. It is an inhabitant of clear running waters, and is well known for its use in bleeding.

2. The sanguisuga, or horse-leech, is larger than the former. Its skin is smooth and glossy; the body is depressed, the back is dusky; and the belly is of a yellowish-green, having a yellow lateral margin. It inhabits stagnant waters.

3. The geometra, or geometrical leech, grows to an inch and a half in length; and has a smooth and glossy skin of a dusky-brown colour, but in some seasons greenish spotted with white. When in motion its back is elevated into a kind of ridge; and it then appears as if measuring the space it passed over, like a compass, whence its name. Its tail is remarkably broad; and it holds as firmly by it as by the head. It is common on stones in shallow running waters; and is often found on trout and other fish after the spawning season.

4. The muricata, or muricated leech, has a taper body, rounded at the greater extremity, and furnished with two small tentacula, or horns, strongly annulated and rugged upon the rings, the tail dilated. It inhabits the Atlantic ocean, and is by the fishermen called the sea-leech. It adheres to fish, and generally leaves a black mark on the spot.

The mouth of the leech is armed with a sharp instrument that makes three wounds at once, and may be compared to the body of the pump, and the tongue or fleshy nipple to the sucker; by the working of this piece of mechanism the blood is made to rise up to the conduit which conveys it to the animal's stomach, which is a membranaceous skin divided into 24 cells. The blood which is sucked out is there preserved for several months, almost without coagulating, and proves a store of provision to the animal. The nutritious parts, pure and already digested by animals, have no call to be disengaged from the heterogeneous substances: nor indeed is there an anus discoverable in the leech: mere transpiration seems to be all that it performs, the matter fixing on the surface of its body, and afterwards coming off in small threads. Of this an experiment may be tried by putting a leech into oil, where it keeps alive for several days; upon being taken out and put into water, there appears to loosen from its body a kind of slough shaped like the creature's body. The organ of respiration, though unascertained, seems to be situated in the mouth; for if, like an insect, it drew its breath through vent-holes, it would not subsist in oil, as by it they would be stopped up.

It is only the first species that is used in medicine, being applied to the skin in order to draw off blood. With this view they are employed to phlebotomise young children. If the leech does not fasten, a drop of sugared milk is put on the spot it is wished to fix on, or a little blood is drawn by means of a slight puncture, after which it immediately settles. The leech when fixed should be watched, lest it should find its way into the anus when used for the hemorrhoids, or penetrate into the œsophagus if employed to draw the gums, as it would make great havoc in the stomach or intestines. In such a case, the best and quickest remedy is to swallow some salt; which is the method practised to make it loose its hold when it sucks longer than was intended. Salt of tartar, volatile alkali, pepper, and acids, make it also leave the

part on which it was applied. Cows and horses have been known to receive them, in drinking, into the throat. The usual remedy is to force down some salt, which makes them fall off. The discharge occasioned by the puncture of a leech is usually of more service than the process itself. When too abundant it is easily stopped with brandy, vinegar, or other styptics, or with a compress of dry linen rag bound strongly on the bleeding orifice.

At Ceylon, travellers who walk bare-legged are molested by the great numbers of leeches concealed under the grass. All leeches vary in their colours at some seasons, but they are generally of a dusky greenish-brown or yellow, and often variegated. They are said to be very restless before a change of weather, if confined in glasses.

HIRUNDO, in ornithology, a genus of birds of the order of passeres. There are 37 species, chiefly distinguished by their colour. The most remarkable are,

1. The rustica, common or chimney-swallow, is distinguished from all the other species by the superior forkiness of its tail, and by the red spot on the forehead and under the chin. The crown of the head, the whole upper part of the body, and the coverts of the wings, are black, glossed with a rich purplish blue, most resplendent in the male: the breast and belly white, and in the male tinged with red. The food of this swallow is the same with the others of its kind, viz. insects. For the taking of these, in their swiftest flight, nature has admirably contrived their several parts: their mouths are very wide to take in flies, &c. in their quickest motions; their wings are long, and adapted for distant and continued flight; and their tails are forked, to enable them to turn the readier in pursuit of their prey. This species is the first comer of all the British hirundines; and appears in general on or about the 13th of April, though now and then a straggler is seen much earlier. This hirundo, though called the chimney-swallow, by no means builds altogether in chimneys, but often within barns and out-houses against the rafters; and so she did in Virgil's time. In Sweden she builds in barns, and is called *ladu swala*, the barn-swallow. Besides, in the warmer parts of Europe there are no chimneys to houses except they are English built: in these countries she constructs her nest in porches, and gateways, and galleries, and open halls. Here and there a bird may effect some odd and peculiar place; but in general with us this species breeds in chimneys, and loves to haunt those stacks where there is a constant fire, no doubt for the sake of warmth. Not that it can subsist in the immediate shaft where there is a fire, but prefers one adjoining to that of the kitchen, and disregards the perpetual smoke of that funnel. Her nest consists, like that of the house-martin, of a crust or shell composed of dirt or mud, mixed with short pieces of straw to render it tough and permanent; with this difference, the shell of the martin is nearly hemispheric, that of the swallow is open at the top, and like half a deep dish: this nest is lined with fine grasses, and feathers which are often collected as they float in the air.

The bird lays from four to six white eggs, dotted with red specks; and brings out her first brood about the last week in June, or the first week in July. The progressive method by which the young are introduced into life is very curious: first, they emerge from the shaft with difficulty enough, and often fall down into the rooms below; for a day or two they are fed on the chimney top, and then are conducted to the dead leafless bough of some tree, where, sitting in a row, they are attended with great assiduity, and may be then called perchers. In a day or two more they become flyers, but are still unable to take their own food; therefore they play about near the place where the dams are hawking for flies; and when a mouthful is collected, at a certain signal given, the dam and the nestling advance, rising towards each other, and meeting at an angle; the young one all the while uttering such a little quick note of gratitude and complacency, that a person must have paid very little regard to the wonders of natore that has not often remarked this feat. The dam betakes herself immediately to the business of a second brood as soon as she is disengaged from her first; which she at once associates with the first broods of house-martins, and with them congregates, clustering on sunny roofs, towers, and trees. This hirundo brings out her second brood towards the middle and end of August.

Each species of hirundo drinks as it flies along, sipping the surface of the water; but the swallow alone, in general, washes on the wing, by dropping into a pool for many times together: in very hot weather house-martins and bank-martins dip and wash a little. The swallow is a delicate songster, and in soft sunny weather sings both perching and flying; on trees in a kind of concert, and on chimney-tops. Horsemen on wide downs are often closely attended by a little party of swallows for miles together, which plays before and behind them, sweeping around, and collecting all the sculking insects that are roused by the trampling of the horses' feet: when the wind blows hard, without this expedient, they are forced to settle to pick up their lurking prey.

This species feeds much on little coleoptera, as well as on gnats and flies; and often settles on dug-ground, or pats, for gravel to grind and digest its food. Mr. White informs us, that before they depart, for some weeks, to a bird, they forsake houses and chimneys, and roost in trees; and usually withdraw about the beginning of October; though some few stragglers may be seen at times till the first week in November. Mr. Pennant says, that for a few days previous to their departure, they assemble in vast flocks on house-tops, churches, and trees, whence they take their flight. They are supposed to take up their winter-quarters in Senegal and parts adjacent, and seem to possess in turn the whole of the old continent, being known from Norway to the Cape of Good Hope on the one hand, and from Kamtschatka to India and Japan on the other. They are also found in all parts of North America, migrating north and south.

2. The esculenta, or edible swallow, according to Buffon, is less than the wren, and only two inches and a quarter in length. The bill is black; the upper parts of the body are brown, the under whitish; the tail is forked, and each feather of it is tipped with white; the legs are brown. See Plate LXXIV. Nat. Hist. fig. 228.

The most curious part of the natural history of this bird consists in the nest, which is composed of such materials as render it not only edible, but one of the greatest dainties of the Asiatic epicures.

These nests are found in vast numbers in certain ca-

verns. in various isles in Soolo Archipelago, situated between longitude 117 and 120, latitude 5 and 7; particularly in three small isles, or rather rocks; in the caverns of which the nests are found fixed to the sides in astonishing numbers. Of these nests, it is said the Dutch alone export from Batavia 1000 pickles, upwards of 1300lb. English weight, every year, which are brought from the isles of Cochin China, and those lying to the east of them.

3. The urbica, or martin, is inferior in size to the chimney swallow, and its tail much less forked. The head and upper part of the body, except the rump, are black, glossed with blue; the breast, belly, and rump, are white; the feet are covered with a short white down. This is the second of the swallow kind that appears in Britain. They begin to appear about the 16th of April. About the middle of May, if the weather is fine, the martin begins to think in earnest of providing a mansion for its family. As this bird often builds against a perpendicular wall without any projecting ledge under, it requires its utmost efforts to get the first foundation firmly fixed, so that it may safely carry the superstructure. That this work may not, while it is soft and green, pull itself down by its own weight, the provident architect has prudence and forbearance enough not to advance her work too fast; but by building only in the morning, and by dedicating the rest of the day to food and amusement, gives it sufficient time to dry and harden. By this method in about 10 or 12 days is formed an hemispheric nest, with a small aperture towards the top, strong, compact, and warm, and perfectly fitted for all the purposes for which it was intended. But then nothing is more common than for the house-sparrow, as soon as the shell is finished, to seize on it as its own, to eject the owner, and to line it after its own manner. At first, when the young are hatched, and are in a naked and helpless condition, the parent birds, with tender assiduity, carry out what comes away from their young. Was it not for this affectionate cleanliness the nestlings would soon be burnt up and destroyed in so deep and hollow a nest by their own caustic excrement. As soon as the young are able to shift for themselves, the dams immediately turn their thoughts to the business of a second brood: while the first flight, shaken off and rejected by their nurses, congregate in great flocks, and are the birds that are seen clustering and hovering on sunny mornings and evenings on round towers and steeples, and on the roofs of churches and houses. As the summer declines the congregating flocks increase in numbers daily, by the constant accession of the second broods, till at last they swarm in myriads round the villages on the Thames, darkening the face of the sky as they frequent the aits of that river, where they roost. They retire in vast flocks together about the beginning of October. Unless these birds are very short-lived indeed, or unless they do not return to the district where they are bred, they must undergo vast devastations somehow, and somewhere; for the birds that return yearly bear no manner of proportion to the birds that retire.

4. The riparia, sand-martin, or shore-bird, is $4\frac{3}{4}$ inches in length, with the whole upper parts of the body of a mouse colour, the throat and under parts white, the bill and legs blackish. It is common about the banks of rivers and sand-pits, where it terebrates a round and regular hole in the sand or earth, which is serpentine, horizontal, and about two feet deep. At the inner end of this burrow the bird deposits her rude nest, consisting of fine grasses and feathers, usually goose-feathers, very inartificially laid together.

5. The apus, or swift, is a large species, being near eight inches long, with an extent of wing near 18 inches, though the weight of the bird is only one ounce. Their feet are so small, that the action of walking and rising from the ground is extremely difficult; but nature has made it full amends, by furnishing it with ample means for an easy and continual flight. It is more on the wing than any other swallow; its flight is more rapid, and that attended with a shrill scream. It rests by clinging against some wall, or other apt body; whence Klein styles this species hirundo muraria. It breeds under the eaves of houses, in steeples, and other lofty buildings; and makes its nest of grasses and feathers. The feet of this species are of a particular structure, all the toes standing forward: the least consists of only one bone; the others of an equal number, viz. two each, in which they differ from those of all other birds: a construction, however, nicely adapted to the purposes in which their feet are employed. See Plate LXXIV. Nat. Hist. fig. 227.

The swift is a summer inhabitant of Great Britain. It comes the latest, and departs the soonest, of any of the tribe; not always staying to the middle of August, and often not arriving before the beginning of May.

6. The melba, or white bellied swift, is in length eight inches and a half, and weighs two ounces five drams.

7. The cayennensis, or white coloured swallow, is about the size of the martin: the head and bill are black; the chin and throat white, passing from the last in a narrow collar round the neck: between the bill and eye is a streak of white, which forks off into two, one passing a little above, and the other a little way beneath the eye: the rest of the plumage is black, with a gloss of violet; but the greater coverts, nearest the body, are brown edged with white. This bird makes its nest in the houses of Cayenne. It is of a large size, in shape of a truncated cone; five inches one way by three the other, and nine inches in length. It is composed of the down of dog's-bane, well woven together; the cavity divided obliquely about the middle, lengthways, by a partition, which spreads itself over that part of the nest where the eggs lie, which is pretty near the base: a small parcel of the same soft down, forming a kind of plug, is placed over the top, serving to keep the young brood from the impression of the air, from which we may suppose them to be very tender.

By the myraids of insects which every single brood of swallows destroys in the course of a summer, they defend us in a great measure from the personal and domestic annoyance of flies and gnats; and, what is of infinitely more consequence, they keep down the numbers of our minute enemies, who, either in the grub or winged state, would otherwise render the labours of the husbandman fruitless. Since then swallows are guardians of our corn, they should every where be protected by the same popular veneration which in Egypt defends the ibis, and the stork in Holland. We more frequently hear of unproductive harvests on the Continent and it is well known

that swallows are caught and sold as food in the markets of Spain, France, and Italy. In England they are not driven to such resources to furnish their tables. But what apology can be made for those, and many there are, whose education and rank should have taught them more innocent amusements, who wantonly murder swallows, under the idle pretence of improving their skill in shooting game? Setting aside the cruelty of starving whole nests of young by killing the dam; those who follow this barbarous diversion would do well to reflect, that by every swallow they kill, they assist blasts, mildews, and vermin, in causing a scarcity of bread. Every lord of a manor should restrain his gamekeeper from this execrable practice; nor should he permit any person to sport on his lands who does not refrain from it.

HISPA, in zoology, a genus of insects belonging to the coleoptera order, the characters of which are these: the antennæ are fusiform, growing gradually larger from each extremity towards the middle, and are situated between the eyes; the thorax and elytra are covered with protuberances or spines. The larva of this insect seems to be yet wholly unknown. There are but two species of the perfect animal met with in Europe; one of which, the atra, is found in Britain, and is all over of a deep unpolished black, and has the upper part of its body entirely covered with long and strong spines, which render it bristly like the shell of a chesnut. There is even a spine at the case of the antennæ; the thorax has a row set transversely, which are forked; and the elytra are furnished with a very great number that are single. Its being thus covered with spines makes it resemble a hedge-hog in miniature. It is rather hard to catch, letting itself fall down to the ground as soon as approached. It bears its antennæ upright before it. See Plate LXXIV. Nat. Hist. fig. 229.

HISTER, a genus of insects of the coleoptera order. The generic character is, antennæ headed by a somewhat solid tip, lowest joint compressed and decurved; head retractile; mouth forcipated; wing-sheaths shorter than the body; fore-legs toothed.

The most common European species of this genus is the hister unicolor of Linnæus. It is entirely of a glossy coal-black colour, and of a slightly flattened shape, varying considerably in size, but usually measuring about the third of an inch in length, and is often seen in gardens, sandy fields, &c. Its larva seems to be unknown.

Hister quadrimaculatus, has much the appearance of a small beetle; its shape is strongly convex, and its colour black, with two dull-red bars on each wing-shell, viz. one at the base, and the other, smaller, at the tip. It is found about dunghills, &c.

HISTORY, *civil.* History, in its simplest definition, implies the mere narration of events and facts; but when placed in its true dignity, it is something more than this, it is philosophy "teaching by examples." The study of it is more or less the employment of all persons of reading and education; and the composition of it was the earliest use that was made of letters, since the first poems were historical: it is calculated for the use of all ranks and all professions in life, and places the reader of its events as a spectator out of all hazards, who may reap wisdom from the danger of others, and foretel, to a certain extent, the future by the past.

The general uses of history are exhibited by Dr. Priestley under three heads: 1. He says, history serves to amuse the imagination, and interest the passions in general. 2. It improves the understanding: and, 3. It tends to strengthen the sentiments of virtue. In the first of these views we find history has a great advantage over every work of fiction: for we consider it as the voice of truth. The second has been aptly illustrated by Bolingbroke, who observes that "He who studies history as he would philosophy, will distinguish and collect certain general principles and rules of life and conduct, which always must be true, because they are conformable to the invariable nature of things; and by doing so he will soon form to himself a general system of ethics and politics on the surest foundations, on the trial of these principles and rules in all ages, and on the confirmation of them by universal experience." And the third is still more evident, from the very light in which characters and events are seen in it. Fame is found just to the dead, however partial to the living.

The sources of history form another topic of inquiry. The earliest of these was undoubtedly tradition; the next, perhaps, poetical narrations; which, though often mixed with the absurdities of fable, contain facts and characters of ancient life that illustrate the manners of the early ages. Coins, medals, and inscriptions, the works of artists of all kinds, and sometimes even rude heaps, are other monuments, whose collateral aids are equally necessary with the astronomical mediums employed by Newton, in the correction of chronology. I later times, as political society increased, the archives and laws of states perpetuated information in a more certain and extended form. The correct knowledge of events was easily obtained. Private experience could be joined to the information contained in public annals; and fair topics were presented to the pen of every man who proposed to himself the task of an historian.

In regard to what is necessary or useful to be known previous to the study of history, it is proper to observe that it must be taken in very different degrees of extent, according to the views with which history is read; and these depend very much upon the age and situation of the person who applies to it. But whoever proposes to study history scientifically, must come to the reading of it furnished with the first principles of certain sciences. If not the knowledge, at least a general idea of the principles of human nature, will be an excellent guide to us in judging of the consistency of human characters, and of what is within and what is without the reach of human powers. Philosophical knowledge, in general, will be found of the most extensive use to all persons who would examine with accuracy the achievements of ancient nations in peace or war, or who would thoroughly weigh the accounts of any thing in which the powers of nature are employed. But those sciences which are of the most constant and general use are geography and chronology. A knowledge of the situation and relative magnitude of the several countries of the earth, assists and affords clear and distinct ideas of events; and a general comprehenion of the current of time enables us distinctly to trace their dependence on each other.

Beside these, however, there are other helps. Obvious advantages will attend the use of a good compendium of general history, previous to the study of any particular portion. The earliest epitome was the Chronicon Carionis, printed at Wittenberg, 1532; but the most celebrated are, Turseline's, Bossuet's, and Baron Holberg's; the last of these was translated into English by Mr. Gregory Sharpe. Of chronological tables the best and most completely useful are Blair's: and of the charts of history, Dr. Priestly's These show at once the reference which the history of one country bears to that of another.

The misapplication to which history is liable, evinces the necessity of prosecuting the study of it according to a regular plan. To those who can reach its sources these directions may be serviceable: principally obtained from Dr. Priestley.

The sacred history may properly be said to stand alone: it is not only the most certain, but exhibits the continuation of the true religion uninterrupted from the creation of the world, and therefore ought to form the ground-work of our study.

The oldest history extant, next to the historical books of the Old Testament, is that of Herodotus, who flourished about four hundred and fifty years before the christian era, a little after the invasion of Greece by Xerxes. His history comprises probably every thing he had an opportunity of learning concerning the history of the Lydians, Ionians, Lycians, Egyptians, Persians, Greeks, and Macedonians: computing from the earliest of his accounts to the latest, his history may be reckoned to commence about seven hundred and thirteen years before Christ, and to reach to about four hundred and seventy-nine before Christ; a period of about two hundred and thirty-four years.

Next to Herodotus, Thucydides is to be read, whose history reaches to the 21st year of the Peloponnesian war, the history of which is completed in the first and second books of Xenophon's History of Greece. After this, the student may proceed to the expedition of Cyrus, and the return of the Greeks: and then go back to the remaining-books of Xenophon's history. The fifteenth and sixteenth books of Diodorus Siculus contain the histories of Greece and Persia from the battle of Mantinæa to the beginning of the reign of Alexander the Great, in the year 336 before Christ. For the history of Alexander, Arrian, Quintus Curtius, and the tenth and eleventh books of Justin must be referred to. The eighteenth, nineteenth, and twentieth books of Diodorus Siculus contain the history of Greece from the year 323 before Christ, to the year 301: the thirteenth, fourteenth, and fifteenth books of Justin will complete the period; and those which follow to the twenty-ninth inclusive, carry on the history to about the year 195 A. C. Lastly, in the regular order of history read the thirteenth book of Justin, and all that follow to the two last, which completes the History of Greece till it mixes with that of the Romans.

The lives of illustrious men by Plutarch and Cornelius Nepos, form an excellent supplement to the regular historians.

Of the above works, which contain not only the History of Greece, but that of all the nations of the world known to the historians, Justin, Quintus Curtius, and Cornelius Nepos, only, are in Latin; the rest are in Greek.

The following course of Roman History comprehends all that is to be learnt now of the subsequent Ancient History of all other nations. The writer who treats of the early part of the Roman history, in the fullest and most satisfactory manner is Dionysius of Halicarnassus, a rhetorician as well as an historian: the remains of his work which originally brought the History of Rome to the beginning of the first Punic war, end at this time with the year 341 before Christ, the time when the consuls resumed the chief authority in the republic after the dissolution of the decemvirate: so that to complete the period we must go to the three first books of Livy, whose history to the tenth book inclusive, brings that of Rome to the year 451, of the building of the city or 292 before Christ. To supply the chasm between the tenth and twentieth books of Livy, read Polybius, the seventeenth, eighteenth, twenty-second, and twenty-third books of Justin, and Appian's Punic and Illyrian wars, and afterwards the remainder of Livy from the twenty-first book to the end, which brings the history to 166 years before Christ. Sallust's History of the war of Jugurtha and the Catalinarim conspiracy, are the next books to be proceeded to: they are all which remains to us of his works. The commentaries of Cæsar, and Cicero's Epistles to Atticus, are the next works to be consulted, followed by the remains of Dio Cassius, and the Compendium of Vellerius Paterculus. Suetonius's Lives of the Cæsars, and the works of Tacitus, close the list of Roman historians of the greatest eminence. Those who are called the writers of the brazen or iron age deserve a slighter mention. The principal of these are, Xiphilin, Herodian, The Historiæ Augustæ Scriptores, Zozimus, Ammianus Marcellinus, Paulus, Deaconus, and Procopius; the last four, however, may be omitted; and Nicetas Acominatus and Nicephorus Gregoras, followed by Joannes Cantacuzenus, substituted in their room. Laonicus Chalcondiles brings up the conclusion of the Eastern Empire, in the year 1453, when Constantinople was taken by Mahomet II.

To enumerate all the modern compilations of ancient history which may be serviceable to those who cannot make their searches in the original authors would be endless. That of Rollin must not be passed over. The most complete body of history, however, ancient and modern, is the Universal: which has references to the original writers for almost every paragraph of information. Gillies and Mitford have written Histories of Greece, and Hooke is by far the most preferable among the compilers of the Roman history.

Having been thus particular on the subject of ancient history, we shall go on to the enumeration of those sources from which the last materials are derived for English history; and then proceeding to the other countries of modern Europe, make a slight mention of the best historians of each.

The earliest accounts of Britain are to be found among the Romans; and principally in the works of Julius Cæsar, Dio Cassius, and Tacitus. Livy and Fabias Rusticus were others who wrote expressly on its history; but their works have perished in the general wreck of ancient literature.

The most ancient of our native historians, now extant, says bishop Nicholson, is Gildas, a monk of Bangor, who lived about the middle of the sixth century; a sorrowful spectator of the miseries and almost utter ruin of his countrymen, by a people under whose banners they hoped for peace. The title of his work was, "De Excidis Britanniæ." The next historian of note was Nennius, who is often confounded with Gildas: his work, which has gone by different names, was printed by Gale under that of "Historia Britonum." If we except a supplement to these writers, in the laws of Hoel Dha, we have nothing more of early British history. Geoffrey of Monmouth's work, which was written at a subsequent period, is nothing more than a romance.

For the history of the Saxon times we have better materials, the oldest of which, perhaps, that are now preserved, are in the Saxon Chronicle, printed from several manuscripts by bishop Gibson. Next to this Bede's Ecclesiastical History may be placed, and the Life of Alfred by Aser of St. David's.

Only two Danish historians, says bishop Nicholson, are necessary to the English antiquary's library; Saxo Grammaticus and Sweno Agonis.

The first English historian after the Norman Conquest, was Ingulph, abbot of Crozland, whose history extends from the year 626 to 1089. That portion of Marianus Scotus's history which relates to Britain never has been printed. Florence of Worcester's, who died 1119, is more full.

Eadmer's work, published by Mr. Selden, contains the history of the two Williams and Henry the First, from 1066 to 1122, and is a work of very good authority.

William of Malmsbury was the next historian, whose book "De Gestis Rebus Anglorum," is one of the most faithful of our numerous annals: it begins with the first arrival of the Saxons, and is continued to the death of Stephen. The other historians of the twelfth century were, Simeon Dunelmensis, Henry of Huntingdon, and William of Neuburg.

Gervase of Canterbury's history, of which a fragment only is left, is the earliest of the thirteenth century: his chief contemporary was Hoveden, who seems to have been chaplain to king Henry the Second. Ralph de Diceto, Walter of Coventry, and Matthew Paris, were others. There were likewise a few meaner historians, whose names it is not necessary to repeat.

The principal writers of the fourteenth century were, Wikes, Trivet, John Brompton, Higden, John of Tinmouth, Matthew of Westminster, and Knighton: the last but one of whom is often called Florilegus.

The first and principal writer of the fifteenth century was Froissart, whose work has been so carefully translated by Mr. Johnes. It affords the best history of the English Nation during the reigns of Edward the Third and Richard the Second. Thomas de Walsingham is the next writer of credit, succeeded by John Harding, Caxton, and Rouse.

Fabian's Chronicle is the first work of consequence in the sixteenth century, and is said to have given great offence to Wolsey. Polydore Virgil's history is not believed to have been so faithful; though greater merit is attributed to the works of Hall and Hollinshead.

The industrious Stowe was the first writer among the historians of the seventeenth century: the next of eminence was Daniel Speed, sir Richard Baker, Sandford, Brady, Echard and Tyrrel, are others, whose names only it is quite sufficient to enumerate.

In the last century, bishop Burnet, Carte, Kennet, Tindal, Hume, Smollet, Macaulay, and Henry, are historians too well known to need either comment or commendation here.

In regard to the writers of particular histories of the kings with whom they were cotemporary, it may be sufficient to enumerate the following: William the Conqueror's life was written by William of Poictiers; king Stephen's memoirs, by Richard Prior of Hexham, printed among the decem-scriptores; Richard the First's Expedition into the Holy Land, was celebrated by Joseph of Exeter, or Iscanus; the Life of Edward the Second by sir Thomas de la More: Henry the Fifth's by some one under the name of Titus Livius: and that of Edward the Fifth, with a part of the History of Richard the Third, by sir Thomas More; Henry the Eighth's Reign, by lord Herbert of Cherbury; and Elizabeth's by Camden. Those of a later period, perhaps, are hardly entitled to so much credit for impartiality.

The historians of other particular countries may be mentioned in a briefer manner; enumerating such only as a reader may refer to when inquiring into facts. In regard to France, after mentioning the Chroniques de St. Denis, the Annales Francorum, with the works of Monstrelet, Mezeray, Daniel and Garnier, and Henault's Abridgement, we need only mention two of the most comprehensive bodies of French history, "Duchesne's Historiæ Francorum Scriptores;" and "Bouquet's Recueil des Historiens des Gaules et de la France," in thirteen volumes folio. For the general history of Italy, Guicciardini's work is undoubtedly the best, not only for its accuracy but its style; though Brusoni's and Capriata's works are much esteemed for their veracity. To those who make a deep search, the "Rerum Italiarum Scriptores," by Muratori, will be useful.

For the separate states of Italy Giannoni's History of Naples, Machiavel's Historia Florentina, and the "Historia Veneziani." For Switzerland, the "Helvetic Confederacy" by Mr. Planta, may be referred to: for Holland, Le Clerc's "Provinces Unies," 1728. Among the writers of German history, the "Germani Scriptores" of Pistorius, Urstilius, Freher, and Reuber, may be mentioned; the writers on ancient Germany by Sicard; the Scriptores Rerum Bronsvicensium; and Mascou's history of the Germans.

The most valuable history of Spain is Mariana's, first published in 1592; the best edition of which, continued to a late period, was published at Valencia 1783. Besides this, Carita's "Annales de Arragon" may be consulted with the "Annales de Cattaluna." The earliest materials for Portuguese history are to be found among the Scriptores Rerum Hispaniarum. The first historian whom Meusel mentions is Laimund de Ortega: but one of the most valuable and industrious was Bernard de Brito, who published the two first parts of the "Monarchia Lusitana," in 1597 and 1609; which was continued as far as an eigth part, in 1729. Others are, Meneze's Historia de Portugal, printed at Lisbon

in two volumes, folio, 1679 and 1698; La Clede's Histoire de Portugal, Par. 1737; and the elaborate history of Gebauer, in German, Leipsig, 1759. On Sweden, Crusius's "Annales Suevicæ," 1596, and Puffendorf "de Rebus Suevicis," 1686, will be found works of considerable consequence. On Norway, Forfæus's "Historia Rerum Norvegicarum." On Denmark, Cragius's "Annales Danicæ;" Mallet's "Histoire de Dannemarc," and Langebek's "Scriptores Rerum Danicarum:" and on Russia, "Rerum Muscovitarum Scriptores," 1600, folio, and Levesque's "Histoire de Russie," 1800. Those who would gain a more particular knowledge of the characters which the principal of these historians bear, may consult the works of Wheare and Rawlinson on History.

There are, however, some particular histories, which are so excellently written, that no person of a liberal education should neglect becoming acquainted with them. Under this character we may comprehend all the works of Tacitus, which now remain to us: in his writings every phrase is a maxim; the narrative goes on with rapidity; while all his characters are drawn with a more profound knowledge of human nature than those of any historian who went before him; his very brevity is pregnant. Thuanus's history of his own times is a work almost equal to any production of the classic ages. Guicciardini's History of Italy: Davila's of the Civil Wars of France; Bentivoglio's of those of the Netherlands; and Giannoni's History of Naples, deserve a similar character, as well as the elegant history of England by Hume. No writer whatever, says Dr. Priestley, can excel Vertot in the happy art of making history entertaining.

There are also periods of history more particularly deserving of a close attention. Among these the connection of sacred and profane history in the succession of the four great monarchies, stands foremost. Another period is that which comprises the history of the Grecian commonwealths, in which the peculiar evils and advantages of a popular government are exhibited with clearness. The rise and declension of the Roman empire is another object for extensive contemplation, as well as the foundation of the present European governments, and the restoration of learning.

We have now only to add a few words on the particular duty of the historian; the model for whom is preserved among the works of Cicero. It is the first law of history, he says, that the writer should neither dare to advance what is false, nor to suppress what is true; that he should relate the facts with strict impartiality, free from ill-will or favour; that his narrative should distinguish the order of time, and when necessary, give the description of places; that he should unfold the statesman's motives, and in his account of the transactions and the events, interpose his own judgment; and should not only relate what was done, but how it was done; and what share, chance, or rashness, or prudence, had in the issue; that he should give the characters of the leading men their weight and influence, their passions, their principles, and their conduct through life. In addition to these, Tacitus gives another rule: "Præcipuum munus annalium reor, ne virtutes sileantur, utque pravis dictis factisque ex posteritate et infamia metus sit:" that it is incumbent on the writer to rejudge the actions of men, to the end that the good and worthy may meet with the reward due to eminent virtue, and that pernicious citizens may be deterred by the condemnation that waits on evil deeds at the tribunal of posterity. In this consists the chief part of the historian's duty.

Let it be remembered that in this country, it is an indispensable duty of every man of liberal birth, to be acquainted in a certain degree with the science of politics. History is the school of politics: it unfolds to us the springs of human affairs; the causes of the rise, grandeur, revolutions, and fall of empires. It points out the reciprocal influence of government and of national manners: it dissipates prejudices, nourishes the love of our country, and directs to the best means of improvement. It illustrates equally the blessings of political union and the miseries of faction.

As to the events that stand recorded in history, says lord Bolingbroke, we see them all, we see them as they followed one another, or as they produced one another, causes or effects, immediate or remote. We are cast back, as it were, into former ages; we live with the men who lived before us, and we inhabit countries that we never saw. Place is enlarged, and time prolonged in this manner; so that the man who applies himself early to the study of history may acquire in a few years, and before he sets his foot abroad in the world, not only a more extended knowledge of mankind, but the experience of more centuries than any of the patriarchs saw. The events we are witnesses of in the course of the longest life, appear to us very often original, unprepared, simple, and unrelative; they appear such very often, are called accidents, and looked upon as the effects of chance: experience can carry us no farther, for experience can go a very little way back in discovering causes; and effects are not the objects of experience till they happen. Hence many errors in judgment, and by consequence in conduct, necessarily arise; and here too lies the difference we are speaking of between history and experience: the advantage on the side of the former is double. In ancient history the examples are complete, which are incomplete in the course of experience; experience is doubly defective; we are born too late to see the beginning, and we die too early to see the end of many things. History supplies both these defects. Modern history shows the causes when experience presents the effects alone; and ancient history enables us to guess at the effects when experience presents the causes alone.

HITCH, in the sea language, is to catch hold of any thing with a hook or rope, and by this means to hold it fast: thus when a boat is to be hoisted in, the sailors say, hitch the tackles into the ring-bolts of the boat; and when they are about to weigh anchor, hitch the fish-hook to the fluke of the anchor.

HIVE, in country affairs, a convenient receptacle for bees. See Apis.

HOARSENESS. See Medicine.

HODMAN, an appellation given to a young student admitted into Christ's College, Oxford, from Westminster-school.

HOE, a husbandman's tool somewhat like a cooper's adze, to cut up weeds in gardens, fields, &c. This instrument is of great use, and ought to be much more employed than it is in hacking and clearing the several cor-

ners and patches of land in spare times of the year, which would be no small advantage to it.

HOEING, in the new husbandry, is the breaking or dividing the soil by tillage while the corn or other plants are growing thereon. It differs from common tillage (which is always performed before the corn or plants are sown or planted) in the time of performing it; and it is much more beneficial to the crops than any other tillage. This sort of tillage is performed various ways, and by means of different instruments.

HOG. See SUS.

HOG, on board of a ship, is a sort of flat scrubbing broom, formed by inclosing a number of short twiggs of birch or such wood between two pieces of plank fastened together, and cutting off the ends of the twigs. It is used to scrape the filth from a ship's bottom under water, particularly in the act of boot-topping. For this purpose they fit to this broom a long staff with two ropes; one of which is used to thrust the hog under the ship's bottom, and the other to guide and pull it up again close to the planks.

HOGSHEAD, in commerce, a measure of capacity, containing sixty-three gallons.

HOLCUS, Indian millet or corn; a genus of the monœcia order, in the polygamia class of plants; and in the natural method ranking under the 4th order, gramina. The calyx of the hermaphrodite is an unifloroas or biflorous glume; the corolla is a glume with an awn; there are three stamina, two styles, and one seed. The male calyx is a bivalved glume; there is no corolla, but three stamina.

Of this genus there are fifteen species, two of which are natives of Britain. The most remarkable of these is the lanatus, or creeping soft-grass of Hudson. The most remarkable of the foreign species is the sorghum, or Guinea-corn. The stalks are large, compact, and full eight feet high. In Senegal the fields are entirely covered with it. The negroes, who call it guiarnot, cover the ears when ripe with its own leaves to shelter it from the sparrows, which are very mischievous in that country. The grain made into bread, or otherwise used, is esteemed very wholesome. With this the slaves in the West Indies are generally fed, each being allowed from a pint to a quart every day. The juice of the stalks is so agreeably luscious, that, if prepared as the sugarcanes, they would afford an excellent sugar.

HOLOCENTRUS. Holocentrus, a genus of the order thoracici; the generic character is, habit of the genus perca; gill-covers scaly, serrated, and aculeated; scales in most species, hard and rough. There are 35 species, the principal of which are:

1. Holocentrus sogo, a highly beautiful species: general length about a foot; habit somewhat resembling that of a carp, but of a squarer form, growing suddenly slender near the tail; eyes very large and gold-coloured; tail very much forked. Native of the Mediterranean, Indian, and American seas, and considered as an excellent fish for the table.

2. Holocentrus schraetzer: length about ten inches; shape somewhat lengthened; head destitute of scales, for which reason this species is by Dr. Bloch arranged under a distinct genus by the name of gymnocephalus: scales rather small than large; tail slightly divided; lowest of the longitudinal lines composed of a row of spots; dorsal fin spotted with black; native of the Danube and its tributary streams; in considerable esteem as an article of food.

3. Holocentrus decussatus, decussated holocentrus: length about twelve inches; back dusky brown; sides marked by two longitudinal brown stripes from the gills to the tail, and by seven transverse ones, each continued to some little distance into the dorsal fin, which is white or pale; scales middle-sized; eyes blue; tail brown, and slightly lunated.

4. Holocentrus calcarifer, spur-gilled holocentrus; length about a foot; habit that of a carp, but rather more lengthened in proportion; body marked by dusky lines along each row of scales; anterior gill-covers furnished with four strong sharp spines, so placed as to bear some resemblance to the rowel of a spur; posterior gill-covers armed with a single spine: fins and tail marked across the rays by brown spotted streaks; native of Japan.

5. Holocentrus surinamensis, Surinam holocentrus: length twelve inches; habit of a carp; general colour brown, with several large, roundish, obscurely-yellow patches on each side; head and gill-covers red; mouth small; dorsal fin scaly at the base of the back-part; tail crossed near the base by a brown bar: native of Surinam, where it is highly esteemed for the table, being considered as one of the best fishes which the country produces.

6. Holocentrus afer, African holocentrus; length twelve inches; outline of the body, exclusive of the fins, somewhat resembling that of a sole; thickness considerable; scales very small, but those on the posterior gill-covers considerably larger than the rest; dorsal fin covered with small scales, and furnished on the fore-part with extremely thick or strong spines; back part and anal fin rounded, and reaching to within a little distance of the tail, which is remarkably small for the size of the fish, and of a round shape; pectoral fins, whitish; ventral, pale red; native of the coast of Guinea, feeding on marine insects, &c. and in considerable estimation as a food.

HOLLY. See ILEX.

HOLOSTEUM, a genus of the trigynia order, in the
HOLLAND, in commerce, a fine and close kind of linen, so called from its being first manufactured in Holland.
triandria class of plants, and in the natural method ranking under the 22d order, caryophyllei. The calyx is pentaphyllous; the petals five; the capsule, unilocular, and nearly cylindrical, opening at top. There are five species.

HOLOTHURIA, in zoology, a genus belonging to the order of vermes mollusca. The body, detached, naked, gibbous, terminated by the anus. Many tentacula at the other extremity surrounding the mouth. There are nine species, all inhabitants of the ocean. The following descriptions of three species are given by Mr. Barbut.

1. The tremula, or quivering holothuria, "commonly measures eight inches in length when dead; but alive it extends itself to more than a foot, or contracts its body into a ball. Its figure is cylindric, the diameter of which is every way equal to an inch and a few lines. The belly is of a pale brown, and set all over with cylindric tentacula, in such numbers that the head of a pin could scarcely find room between. By the help of these tentacula,

the holothuria fixes its body at the bottom of the sea, so as not to be easily forced away by tempests, which would otherwise happen the more frequently, as this zoophite dwells near the shores where the water scarcely rises to a fathom's height.

2. The physalis, or bladder-shaped holothuria. The body of this species is oval, approaching to triangular, of a glossy transparency; the back sharp-edged, of a dark green colour, whence run out a number of sinews; anteriorily the body is of a reddish hue. The trunk spiral, reddish towards the thicker end. Many tentacula of unequal length under that thicker end; the shorter ones are taper and thicker, the middle ones capillary, the point clay-colour, and in shape like a ball; the rest, which are longer, are filiform, of which the middlemost is thicker and twice as long. Brown, in his Jamaica, calls it a diaphanous bladder with numerous tentacula representing a man's belly; above it is furnished with a comb full of cells; under the other extremity hang a number of branchy tentacula. It inhabits the seas.

3. The pentactes, or five rowed holothuria, has the mouth encompassed with tentacula, the body bearing tentacula five different ways. The animal is of a red colour, nearly oval, or somewhat cylindrical, assuming various shapes. The mouth is set round with ten rays, bristly at the points; the body is longitudinally dotted with warts. It inhabits the sea of Norway.

HOLY-GHOST, *order of the*, the principal military order in the old government of France, instituted by Henry III. in 1569.

HOLLOW-SQUARE, in the military art, a body of foot drawn up, with an empty space in the middle for colours, drums, and baggage.

Hollow-tower, according to Harris, is a rounding made of the remainder of two brisures, to join the curtin to the orillon, where the small shot are played, that they may not be so much exposed to the view of the enemy.

HOMAGE. In the original grants of lands and tenements by way of fee, the lord did not only tie his tenants to certain services, but also took a submission, with promise and oath to be true and loyal to him as their lord and benefactor. This submission was and is called homage.

Homage Ancestrel, is where a man's ancestors, time out of mind, held their land of their lord and his ancestors, by homage; and if such lord has received homage, he is bound to acquit the tenant against all other lords above him of all service; and if the tenant has done homage to his lord, and is impleaded, and vouches the lord to warranty, the lord is bound to warrant him; and if the tenant loses, he shall recover in value against the lord so much of the lands as he had at the time of the voucher, or any time after.

Homage Jury, a jury in a court baron, consisting of tenants that do homage to the lord of the fee, and there by the feudists are called pares curiæ; they inquire and make presentments of defaults and deaths of tenants, admittances, and surrenders in the lord's court, &c.

HOMALIUM, a genus of the class and order polyandria trigynia. The calyx is six or seven-parted: corolla, six or seven-petalled: stamina, 21 in three bodies: pericarpium, one-celled, many-seeded. There are two species, a tree of Jamaica and a shrub of Guiana.

HOMICIDE, properly so called, is the killing of a man by a man. Of this there are several species, as homicide by self-defence, homicide by misadventure, justifiable homicide, manslaughter, chance-medley, and murder.

Homicide by self-defence. Homicide se defendendo, or in a man's own defence, seems to be, where one has no other possible means of preserving his life from one who combats with him on a sudden quarrel, and kills the person by whom he is reduced to such inevitable necessity. 1 Haw. 75.

And not only he who on an assault retreats to a wall, or some such strait, beyond which he can go no farther before he kills the other, is judged by the law to act upon unavoidable necessity; but also he, who being assaulted in such a manner and in such a place, that he cannot go back without manifestly endangering his life, kills the other without retreating at all. Id.

And though a person who retreats from an assault to the wall should give the other wounds in his retreat, yet if he gives him no mortal wound till he gets thither, and then kills him, he is guilty of homicide se defendendo only. Id.

But if the mortal wound was given first, then it is manslaughter. Hale's Pl. 42.

Homicide by misadventure, is where a man in doing a lawful act without any intent of hurt, unfortunately chances to kill another, as where a labourer being at work with an hatchet, the head thereof flies off, and kills one who stands by. 1 Haw. 73.

It seems clear, that neither homicide by misadventure, nor homicide se defendendo are felonious, because they are not accompanied with a felonious intent, which is necessary in every felony. 1 Haw. 29.

Justifiable homicide. To make homicide justifiable, it must be owing to some unavoidable necessity, to which a person who kills another must be reduced, without any manner of fault in himself.

And there must be no malice coloured under pretence of necessity; for wherever a persons who kills another, acts in truth upon malice, and takes occasion upon the appearance of necessity to execute his own private revenge, he is guilty of murder. 1 Haw. 69.

But if a woman kills him who assaults to ravish her, it is no felony; or if a man comes to burn my house, and I go out thereof and kill him, it is no felony. Id. 39.

If any evil-disposed person shall attempt feloniously to rob or murder any person in any dwelling-house, or highway, or feloniously attempt to break any dwelling-house in the night time, and shall happen to be slain in such felonious attempt, the slayer shall be discharged, and shall forfeit no lands, nor goods. 24 H. VIII. c. 5.

Justifiable homicide of a public nature, is such as is occasioned by the due execution or advancement of public justice, with regard to which it must be observed.

1. That the judgment, by virtue whereof any person is put to death, must be given by one who has legal jurisdiction in the cause; for otherwise both judge and officer may be guilty of felony.

2. The execution must be pursuant to, and warranted by the judgment, otherwise it is without authority; and consequently, if a sheriff shall behead a man, when it is

no part of the sentence to cut off the head, he is guilty of felony. 1 Haw. 70.

Manslaughter. Homicide against the life of another, is either with or without malice; that which is without malice is called manslaughter, or sometimes chance medley, by which is understood such killing as happens either on a sudden quarrel, or in the commission of an unlawful act, without any deliberate intention of doing any mischief at all. 3 Inst. 56.

Hence it follows, that there can be no accessaries to this offence before the fact, because it must be done without premeditation; but there may be accessaries after the fact. Id.

The only difference between murder and manslaughter, is, that murder is upon malice aforethought, and manslaughter upon a sudden occasion, as if two meet together, and striving for the wall the one kills the other, this is manslaughter and felony. And so it is if they had, on that sudden occasion, gone into the field and fought, and the one had killed the other, this had been but manslaughter and no murder, because all that followed was but a continuance of the first sudden occasion, and the blood was never cooled till the blow was given. 3 Inst. 55.

Chance or chaunce-medley. Authors of the first authority disagree about the application of this word; by some it is applied to homicide by misadventure, by others to manslaughter. The original meaning of the word seems to favour the former opinion, as it signifies a sudden or casual meddling or contention; but homicide by misadventure supposes no previous meddling or falling out.

Murder is the highest crime against the law of nature that a man is capable of committing.

Murder is when a man of sound memory, and at the age of discretion, unlawfully kills another person under the king's peace with malice aforethought, either expressed by the party, or implied by the law, so as the party wounded or hurt die of the wound or hurt within a year and a day. 3 Inst. 47.

And the whole day on which the hurt was done, shall be reckoned the first. 1 Haw. 79.

By malice expressed, is meant a deliberate intention of doing any bodily harm to another, whereunto by law a person is not authorized.

And the evidences of such malice must arise from external circumstances discovering that inward intention; as lying in wait, menacings antecedent, former grudges, deliberate compassings and the like, which are various, according to the variety of circumstances. 1 H. H. 451.

Malice implied, is where a person voluntarily kills another, without any provocation; for in this case the law presumes it to be malicious, and that he is a public enemy of mankind. 1 H. H. 455.

In general any formed design of doing mischief may be called malice; and therefore not such killing only as proceeds from premeditated hatred or revenge against the person killed, but also in many other cases, such as is accompanied with circumstances which show the heart to be perversely wicked, is judged to be of malice prepense, or aforethought, and consequently murder. 2 Haw. 80.

If a man kills another, it shall be intended prima facie that he did it maliciously, unless he makes the contrary appear, by showing that he did it on a sudden provocation or the like. 1 Haw. 82.

When the law makes use of the term malice aforethought as descriptive of the crime of murder, it must not be understood in that narrow restrained sense, to which the modern use of the word malice is apt to lead one, a principle of malevolence to particulars; for the law by the term malice, in this instance, means, that the fact has been attended with such circumstances as are the ordinary symptoms of a wicked heart, regardless of social duty, and fatally bent upon mischief. Fost. 256.

The law so far abhors all duelling in cold blood, that not only the principal who actually kills the other, but also his seconds are guilty of murder, whether they fought or not; and it is holden that the seconds of the person killed are also equally guilty, in respect to that countenance which they give to their principals in the execution of their purpose, by accompanying them therein, and being ready to bear a part with them. 1 Haw. 82.

Also it seems agreed, that no breach of a man's word or promise, no tresspass either to land or goods, no affront by bare words or gestures, however false or malicious it may be, and aggravated with the most provoking circumstances, will excuse him from being guilty of murder who is so far transported thereby, as immediately to attack the person who offends, in such a manner as manifestly endangers his life, without giving him time to put himself upon his guard, if he kills him in pursuance of such assault, whether the person slain did at all fight in his defence or not. Id.

HOMINE REPLEGIANDO, in law, is an ancient writ that lies for bailing a person out of prison, where any one is confined without commandment of the king or his judges; or for any cause that is repleviable. This writ is directed to the sheriff, commanding him to replevy the prisoner. In case a person takes away secretly, or keeps in his custody any person against his will, on oath made thereof, and a petition to the lord chancellor, he will grant a writ of replegiari facias, upon which the sheriff returns an elongatus, and then there issues a capias in withernam, to take the party so offending.

HOMOGENEOUS SURDS, those which have the same radical character, or signs, as $\sqrt[2]{a}$ and $\sqrt[2]{b}$.

HOMOLOGOUS, in geometry, an appellation given to the corresponding sides and angles of similar figures, as being proportional to each other.

HOMOLOGOUS THINGS, in logic, those which agree in name, but are of different natures.

HONEY, a saccharine substance prepared by the bees (see APIS). It has a white or yellowish colour, a soft and grained consistence, a saccharine and aromatic smell. By distillation it affords an acid phlegm and an oil, and its coal is light and spongy like that of the mucilage of plants. Nitric acid extracts from it oxalic acid precisely as it does from sugar; it is very soluble in water, with which it forms a syrup, and like sugar passes to the vinous fermentation. Mr. Cavezzali has proved lately that honey is composed of sugar, mucilage, and an acid. The sugar may be separated by melting the honey, adding carbonat of lime in powder as long as any effervescence appears, and scumming the solution while hot. The liquid thus treated gradually deposits crystals of sugar when allowed to remain in a glass vessel. There are

three distinctions of honey, according to its purity, fluidity, and the manner in which it has been procured from the honey-combs. The first and finest kind is virgin-honey, or the first produce of a swarm, obtained from the combs without pressing; these being only set to drain, in order to its running out. The second kind is that known by the name of white-honey, being thicker than the former, and often indeed almost solid; it is procured by pressing the combs, but without the assistance of heat. The third and worst kind is the common yellow honey, obtained from the combs first heated over the fire, and then pressed.

Honey-comb, a waxen structure, full of cells, framed by the bees, to deposit their honey and eggs in.

The construction of the honey-comb seems one of the most surprising of the works of insects, and the materials of which it is composed, which, though evidently collected from the flowers of plants, yet do not, that we know of, exist in them in that state, has given great cause of speculation to the curious. The regular structure of the comb is also equally wonderful. When the several cells in it are examined, it should seem that the nicest rules of geometry had been consulted for its composition, and all the advantages that could be wished, or desired, in a thing of that kind, are evidently found in it. Each cell consists of six plane sides, which are all trapeziums, but equal to each other; the bottom of the cell is contrived with three rhombuses, H K D I, D E F I, and F G H I, (plate LXXII. Miscel. fig. 124) so disposed as to constitute a solid angle at I, under the three equal angles D I H, D I F, and H I F, each of which is double the maximum angle of $54^{\circ} 44' =$ D I K = D K I. Hence it comes to pass, that a less quantity of surface is sufficient to contain a given quantity of honey, than if the bottom had been flat, in the proportion of 4658 to 5550, as has been found by calculation; that is, nearly a fifth of the whole, so far as the figure in the end of the cells extends, in each; which fifth part of wax and labour saved, amounts to a vast deal in the whole comb. The sides of the cells are all much thinner than the finest paper, and yet they are so strengthened by their disposition, that they are able to resist all the motions of the bee within them, as they are frequently obliged to be. The effect of their thrusting their bodies into the cells would be the bursting of those cells at the top, was not this well-guarded against. But to prevent this, the creatures extend a cord, or roll of wax, round the verge of every cell, in such a manner that it is scarcely possible they should split in that particular part. This cord or roll is at least three times as thick as the sides of the cell, and is even much thicker and stronger at the angles of the cells, than elsewhere, so that the aperture of each cell is not regularly hexagonal, though its inner cavity is perfectly so. See fig. 125.

The several combs are all placed parallel to one another (fig. 126) and there is such a space left between them, that the bees can easily pass; and often they place a part of the comb in a contrary direction to the rest, so that while the others are placed horizontally, these stand perpendicularly.

The celerity with which a swarm of bees received into a hive, where they find themselves lodged to their minds, bring their works of the combs to perfection is amazing. There are vast numbers at work all at once; and that they may not incommode one another, they do not work upon the first comb till it is finished, but when the foundation of that is laid, they go to work upon another, so that there are often the beginnings of three or four stories made at once, and so many parties allotted to the carrying on the work of each. In a very few days a new swarm will have completed several combs of the depth of four or five inches each.

Honey-stone. See Melite.

HONOUR, is used for a seignory or lordship, on which inferior lordships and manors depend; for as a manor consists of several lands, tenements, services, and customs, so an honour contains several manors, knights-fees, &c.

Honour-courts, are courts held within the honours or seignories.

Honour, *maids of*, are six young ladies in the household of the queen, and princess royal; the salary of those of a queen are 300*l.* each, and those of the princess dowager of Wales, 200*l.*

Honour-point, in heraldry, is that next above the centre of the escutcheon, dividing the upper part into two equal portions.

HOOF, the horny substance that covers the feet of divers animals, as oxen, horse, sheep, &c. See Horn.

HOOPING-COUGH. See Medicine.

HOP. See Humulus.

HOPEA, a genus of the polyandria order, in the polyadelphia class of plants. The calyx is quinquefid, superior; the corolla pentapetalous; the stamina are many, and coalited into five pencils; there is one style; the fruit is a plum, with a trilocular kernel. There is only one species, the tinctoria, a native of Carolina.

HORARY, or Hour-circle. See *Use of the* Globe.

Horary circle, or lines. See Dialling.

Horary motion *of the earth*, the arch it describes in the space of an hour, which is nearly 15 degrees, though not accurately so, as the earth moves with different velocities, according to its greater or lesser distance from the sun.

HORDEUM, *barley*; a genus of the triandria-trigynia class of plants, the corolla whereof consist of two valves; the inferior valve is angular, of an ovato-accuminated figure, bellied, and longer than the cup, and terminates in a very long arista; the anterior valve is lanceolated, plane and smaller; the corolla serves as a pericarpium, surrounding the seed, and not letting it out; the seed is oblong, ventricose, pointed at each end, and marked with a longitudinal furrow. See Husbandry.

HORIA, in entomology, a genus of the coleoptera order. Antennæ, moniliform; feelers four, thicker towards the tip; lip linear, rounded at the end. There are two species; the testacea, and the dermestoides.

HORIZON. See Astonomy and Geography.

HORIZONTAL dial. See Dialling.

Horizontal line. See Perspective.

Horizontal plane, that which is parallel to the horizon of the place, or nothing inclined thereto. The business of levelling is to find whether two points are in the horizontal plane, or how much the deviation is.

Horizontal range *of a piece of ordnance*, is the distance at which it falls on or strikes the horizon, or on a horizontal plane, whatever is the angle of elevation or

direction of the piece. When the piece is pointed parallel to the horizon, the range is then called the point-blank, or point-blanc range.

The greatest horizontal range, in the parabolic theory, or in a vacuum, is that made with the piece elevated to 45 degrees, and is equal to double the height from which a heavy body must freely fall to acquire the velocity with which the shot is discharged. Thus, a shot being discharged with the velocity of v feet per second; because gravity generates the velocity $2g$ or $32\frac{1}{6}$ feet in the first second of time, by falling $16\frac{1}{12}$ or g feet, and because the spaces descended are as the squares of the velocities, therefore as $4g^2 : v^2 :: g \frac{v^2}{4g}$, the space a body must descend to acquire the velocity v of the shot or the space due to the velority v; consequently the double of this, or $\frac{x^2}{2g} = \frac{v^2}{32\frac{1}{6}}$ is the greatest horizontal range with the velocity v, or at an elevation of 45 degrees; which is nearly half the square of a quarter of the velocity.

In other elevations, the horizontal range is as the sine of double the angle of elevation; so that, any other elevation being e, it will be, as radius $1 : \sin. 2e :: \frac{v^2}{32\frac{1}{6}} : \frac{v^2}{32\frac{1}{6}} \times \sin. 2e$, the range; at the elevation e, with the velocity v.

But in a resisting medium, like the atmosphere, the actual ranges fall far short of the above theorems, insomuch that with the great velocities the actual or real ranges may be less than the tenth part of the potential ranges; so that some balls, which actually range but a mile or two, would in vacuo range 20 or 30 miles. And hence also it happens that the elevation of the piece, to shoot farthest in the resisting medium, is always below 45°, and gradually the more below it as the velocity is greater; so that the greater velocities with which balls are discharged from cannon with gunpowder, require an elevation of the gun equal to but about 30°, or even less. And the less the size of the balls is too, the less must this angle of elevation be to shoot the farthest with a given velocity. See PROJECTILE and GUNNERY.

HORN, *cornu*, in physiology, a hard substance growing on the heads of animals, particularly the cloven-footed quadrupeds; and serving them both as weapons of offence and defence.

Horns are not very hard, as they may be easily cut with a knife or rasped with a file; but they are so tough as not to be capable of being pounded in a mortar. When in thin plates, they have a degree of transparency, and have been sometimes substituted for glass in windows. When heated sufficiently, they become very soft and flexible, so that their shape may be altered considerably. Hence they may be gradually squeezed into a mould, and wrought into various forms, as is well known. The quantity of earthy matter which they contain is exceedingly small. Mr. Hatchett burnt 500 grains of ox-horn. The residuum was only 1.5 grain, and not the half of this was phosphat of lime. Seventy-eight grains of the horn of the chamois left only 0.5 of residue, of which less than the half was phosphat of lime. They consist chiefly of a membranous substance, which possesses the properties of coagulated albumen; and probably they contain also a little gelatine. Hence we see the reason of the products that are obtained when these substances are subjected to distillation.

The horns of the hart and buck must, however, be excepted. From the experiments of Scheele and Roulle, together with those of Hatchett, we know that these substances possess exactly the properties of bone, and are composed of the same constituents, excepting only that the proportion of cartilage is greater. They are intermediate, then, between bone and horn.

The nails, which cover the extremities of the fingers, are attached to the epidermis, and come off along with it. Mr. Hatchett has ascertained that they are composed chiefly of a membranous substance, which possesses the power of coagulated albumen. They seem to contain also a little phosphat of lime. Water softens, but does not dissolve them. But they are readily dissolved and decomposed by concentrated acids and alkalies. Hence it appears that nails agree with horns in their nature and composition. Under the head of nails must be comprehended the talons and claws of the inferior animals, and likewise their hoofs, which differ in no respect from horn.

The substance called tortoise-shell is very different from shells in its composition, and approaches much nearer to the nature of nail: for that reason we have placed it here. When long macerated in nitric acid, it softens, and appears to be composed of membranes laid over each other, and possessing the properties of coagulated albumen. When burnt, 500 grains of it yield three of earthy matter, consisting of phosphat of lime and soda, with a little iron.

The scales of animals are of two kinds: some, as those of serpents and other amphibious animals, have a striking resemblance to horn; while those of fish bear a greater resemblance to mother-of-pearl. The composition of these two kinds of shells is very different.

The scales of fish, as has been observed by Lewenhoeck, are composed of different membranous laminæ. When immersed for four or five hours in nitric acid, they become transparent, and perfectly membranaceous. The acid, when saturated with ammonia, gives a copious precipitate of phosphate of lime. Hence they are composed of alternate layers of membrane and phosphat of lime. To this structure they owe their brilliancy. Mr. Hatchett found the spicula of the shark's skin to be similar in its composition, but the skin itself yielded no phosphat of lime.

The horny scales of serpents, on the other hand, are composed alone of a horny membrane, and are destitute of phosphat of lime. They yield, when boiled, but slight traces of gelatine: the horn-like crust which cover certain insects and other animals appear from Mr. Hatchett's experiments to be nearly similar in their composition and nature.

The casting of the horns of deer is a singular phænomenon, the true reason of which seems to be a stoppage of the circulation; so that being deprived of the nourishing juice, they fall off much in the same manner as the leaves of trees in autumn. About ten days after the horns are cast, the new ones begin to appear: these at

first are soft and hairy, but they afterwards grow hard, and the creature rubs off the hair.

Horns make a considerable article in the arts and manufactures. Bullocks' horns, softened by the fire, serve to make lanthorns, combs, knives, ink-horns, tobacco-boxes, &c.

Dyeing of horns. Black is performed by steeping brass in aqua-fortis till it is turned green: with this the horn is to be washed once or twice, and then put into a warmed decoction of logwood and water. Green is begun by boiling it, &c. in alum-water, then with verdigris, ammoniac, and white-wine vinegar, keeping it hot therein till sufficiently green. Red is begun by boiling it in alum-water, and finished by decoction in a liquor compounded of quicklime steeped in rain-water, strained, and to every pint an ounce of Brazil wood added. In this decoction the bone, &c. is to be boiled till sufficiently red.

Dr. Lewis informs us, that horns receive a deep black stain from solution of silver. It ought to be diluted to such a degree as not sensibly to corrode the subject, and applied two or three times, if necessary, at considerable intervals, the matter being exposed as much as possible to the sun, to hasten the appearance and deepening of the colour.

Dyeing or staining horn to imitate tortoise-shell. The horn to be dyed must be first pressed into proper plates, scales, or other flat form, and the following mixture prepared: Take of quick-lime two parts, and of litharge one part: temper them together to the consistence of a soft-paste with soap ley. Put this paste over all the parts of the horn, except such as are proper to be left transparent, in order to give it a near resemblance of the tortoise-shell. The horn must remain in this manner covered with the paste till it is thoroughly dry; when, the paste being brushed off, the horn will be found partly opaque and partly transparent, in the manner of tortoise-shell, and when put over a foil of the kind of latten called assidue, will be scarcely distinguishable from it. It requires some degree of fancy and judgment to dispose of the paste in such a manner as to form a variety of transparent parts, of different magnitudes and figures, to look like the effect of nature: and it will be an improvement to add semitransparent parts, which may be done by mixing whiting with some of the paste to weaken its operation in particular places, by which spots of a reddish brown will be produced, which if properly interspersed, especially on the edges of the dark parts, will greatly increase both the beauty of the work and its similitude to real tortoise-shell.

Horn is also a musical intrument of the wind kind, chiefly used in hunting, to animate the hunters and the dogs, and to call the latter together. The French horn is bent into a circle, and goes two or three times round, growing gradually largar and wider towards the end, which in some horns is nine or ten inches over.

Horns *of insects*, the slender oblong bodies projected from the heads of those animals, and otherwise called antennæ or feelers. See Entomology.

HORNBLENDE. This mineral enters into the composition of many mountains. It is also amorphous, but frequently also crystallized. The primitive form of its crystals is a rhomboidal prism, the faces of which are inclined at angles of 124° 34′ and 55° 26′, and whose bases are angles of 122° 56′ and 57° 4′. The most common variety is a six-sided prism, terminated by trihedral or tetrahedral summits.

Hornblende, *common*. Its texture is very conspicuously foliated; fracture conchoidal; fragments often rhomboidal; opaque; tough; specific gravity 2.922 to 3.41; colour black, blackish-green, olive-green, or leek-green; streak greenish. It neither becomes electric by friction nor heat. Before the blow-pipe it melts into a black glass. A specimen of black hornblende, analysed by Mr. Hermann, was compossed of

37	silica
27	alumina
25	iron
5	line
3	magnesia
97	

Hornblende, *basaltic*. This stone is found commonly in basaltic rocks; hence the name *basaltine*, which was imposed by Mr. Kirwan. It is crystallized either in rhomboidal prisms, or six or eight-sided prisms, terminated by three-sided pyramids. Its texture is foliated; its fracture uneven; specific gravity 3.333; colour black, dark-green, or yellowish-green; streak white; transmits a reddish-yellow light. Before the blow-pipe it melts into a greyish-coloured enamel, with a tint of yellow. A specimen, seemingly of this stone, analysed by Bergman, contained

58	silica
27	alumina
9	iron
4	lime
1	magnesia
99	

Hornblende, *shistose*. Colour greenish-black or deep green; forms strata; structure shistose; texture radiated or fibrous; opaque; brittle; streak greenish grey; moderately heavy; gives an argillaceous smell when breathed upon. This mineral is often confounded with slate. In Sweden it is employed for covering houses.

HORNERS, those artificers whose business it is to prepare various utensils of the horns of cattle. The horners were a very ancient and considerably fraternity in the city of London some hundred years ago. In the reign of Edward II. they complained to parliament, that by foreigners buying up the horns in England, they were in danger of being ruined, and this business lost to the nation. For this reason was made the statute 6 Edw. IV. by which the sale of horns to foreigners (except such as the said horners refused) was prohibited; and the wardens had power granted them to search all the markets in London and 24 miles round, and to inspect Stourbridge and Ely fairs, to prevent such practices, and to purchase horns at stated prices. But on plausible pretences this law was repealed in the reign of James I. and thereupon the old evil revived. The horners again applied to parliament, and king Edward's statute was renewed (excepting as to the inspection of the fairs), and still remains in force. The importation of unwrought horns into that country is also prohibited. The present company of horners were incoporated January 12, 1638.

Horn-fish, a species of esox, otherwise called garfish. See Esox.

Horn-work, in fortification, an out-work composed of two demi-bastions, joined by a curtin. See Fortification.

HORNET, in zoology, a species of vespa with a black thorax, and double black spots on the segments of the body. See Vespa.

HORNSTONE, in mineralogy. This stone is usually amorphous, occurring sometimes in mass, and sometimes in round balls. Fracture splintery, and sometimes conchoidal; specific gravity 2.7; colour greyish-blue, but sometimes grey, red, blue, green, and brown, of different shades. According to Kirwan, it is composed of

72	silica
22	alumina
6	carbonat of lime
100	

HORSE. See Equus.

Horse-dealers. Every person exercising the trade or business of a horse-dealer, must take out a licence from the stamp-office, for which he shall pay annually, if within London, Westminster, the bills of mortality, the parish of Pancras, or the borough of Southwark, 20*l.*; elsewhere, 10*l.*

The commissioners are to grant licences to horse-dealers for not exceeding one year; and every license shall cease on September 29, then in the year for which the same shall be issued, and commence from the date; and every licence taken out for any year subsequent to the year in which the same shall be issued, shall commence from September 29, then next ensuing, and continue till September 29 following; and a fresh licence is to be taken out ten days at least before the expiration of the year.

One licence is sufficient for partners, and the licence is confined to the place mentioned thererein. But no licences to be granted to horse-dealers, unless they declare they seek their living by buying and selling horses, and add the name of the place where the said business is carried on. 29 Geo. III. c. 49.

Horse-dealers so licenced, shall cause the words *licenced to deal in horses* to be painted or written in large and legible characters either on a sign hung out or on some visible place in the front of their house, gate-way, or stables; and if they shall sell any horse without fixing such token, they shall forfeit 10*l.* to be recovered by action, half to the king, and half to the informer. 36 Geo. III. c. 17.

Horse-dealers who shall, after January 1, 1796, carry on the said business without having obtained a licence under this act, shall be liable to be assessed the duties on riding-horses, and shall deliver lists thereof as other persons.

Horse-shoe, in fortification, is a small work, sometimes of a round and sometimes of an oval figure, inclosed with a parapet, sometimes raised in the moat or ditch, or in low grounds, and sometimes to cover a gate, or to serve as a lodgment for soldiers. See Fortification.

Horse-shoes. See Farriery.

Horse, in a ship, is a rope made fast to each yard arm, and on which the men stand to furl the sails. It is also a wooden frame with a rowel fixed in it, made use of by the riggers to woold ships-masts.

HORSES. It shall be lawful for any person, native or foreigner, at any time to ship, lade, and transport by way of merchandize, horses into any parts beyond the seas in amity with his majesty, paying for each horse, mare, or gelding, 5*s.* and no more.

No person convicted for feloniously stealing a horse, gelding, or mare, shall have the privilege of clergy. 1 Edw. VI. c. 12. And not only all accessaries before such felony done, but also all accessaries after such felony, shall be deprived and put from all benefit of their clergy, as the principal, by statute heretofore made, is or ought to be.

If a horse be stolen out of the stable, or other curtilage of a dwelling-house, in the night time, it falls under the denomination of burglary; if in the day-time, it falls under the denomination of larceny from the house; and in either case there is a reward of 40*l.* for convicting an offender, and the prosecutor is entitled to a certificate which will exempt him from all parish and ward offices in the parish and ward where the burglary or larceny is committed, and which may be once assigned over, and will give the same exemption to the assignee as to the original proprietor. Burn's Just. 621.

If an unsound horse is sold at the price of a sound horse, though not absolutely warranted to be sound, the seller sins against the law of morality and the law of the land; but if he acknowledges him not to be sound, and sells him greatly under the value of a sound horse, as if he disposes of him for 25*l.* when he would have been worth 50*l.* if sound, such sale may be considered as fair and legal.

If a horse which is warranted sound at the time of sale is proved to have been at that time unsound, it is not necessary that he should be returned to the seller. No lapse of time elapsed after the sale will alter the nature of a contract originally false. Neither is notice necessary to be given; though the not giving notice will be a strong presumption against the buyer, that the horse at the time of sale had not the defect complained of, and will make the proof on his part much more difficult. The bargain is complete; and if it is fraudulent on the part of the seller, he will be liable to the buyer in damages, without either a return or notice.

If on account of a horse warranted sound, the buyer shall sell him again at a loss, an action might *perhaps* be maintained against the original seller, to recover the difference of the price. 1 Hen. Black. 17.

Slaughtering horses. Great abuses having arisen, and many horses having been stolen, from the facility and safety of disposing of them to those who keep slaughter-houses for horses, some regulations and restrictions seemed abolutely necessary. It was no uncommon thing for horses of great value to be sold for the purpose of making food for dogs; the thief rather choosing to receive 20*s.* for a stolen horse, without fear or danger of detection, than venture to dispose of him publicly, though he might possibly have found a purchaser who would have given as many pounds for him. These considerations induced the legislature to pass the act of 26 Geo. III. c. 71, for regulating these slaughter-houses.

Killing or maiming horses. Where any person shall in

the night-time maliciously, unlawfully, and willingly kill or destroy any horses, sheep, or other cattle, of any person, every such offence shall be adjudged felony, and the offender shall suffer as in the case of felony. 22 and 23 Car. II. c. 7.

Offenders may be transported for seven years, either at the assizes or at the sessions, by three justices of the peace, one to be of the quorum.

By the 9th Geo. I. c. 22. commonly called the black-act, it is enacted, that if any person shall unlawfully and maliciously kill, maim, or wound any cattle, every person so offending, being thereof lawfully convicted in any county of England, shall be adjudged guilty of felony, and shall suffer death, as in cases of felony, without benefit of clergy. But not to work corruption of blood, loss of dower, nor forfeiture of lands or goods.

Prosecution upon this statute shall or may be commenced within three years from the time of the offence committed, but not after.

If an horse or other goods are delivered to an innkeeper or his servants, he is bound to keep them safely, and restore them when his guest leaves the house. 2 Black. 451.

If an horse is delivered to an agisting farmer, for the purpose of depasturing in his meadows, he is answerable for the loss of the horse, if it is occasioned by the ordinary neglect of himself or his servants. Jones on Bailm. 91.

If a man rides to an inn, where his horse has eaten, the host may detain the horse till he is satisfied for the eating, and without making any demand. 14 Vin. Abr. 437. But an horse committed to an inn-keeper can only be detained for his own meat, and not for that of his guest or any other horse; for the chattels in such case are only in the custody of the law for the debt which arises from the thing itself, and not for any other debt due from the same party. 2 Rol. Abr. 85.

By the custom of London and Exeter, if a man commits an horse to an inn-keeper, if he eats out his price, the inn-keeper may take him as his own, upon the reasonable appraisement of four of his neighbours; which was it seems a custom arising from the abundance of traffic with strangers, that could not be known so as to be charged with an action. But it has been holden, though an inn-keeper in London may, after long keeping, have the horse appraised and sell him, yet, when he has in such case had him appraised, he cannot justify the taking him to himself at the price he was apprised at. Vin. Abr. 233.

HORTUS siccus, a *dry garden*, an appellation given to a collection of specimens of plants, carefully dried and preserved. The value of such a collection is very evident, since a thousand minutiæ may be preserved in the well-dried specimens of plants, which the most accurate engraver would have omitted.

Among the different methods adopted by botanists for obtaining a hortus siccus, the following appear to be the most practicable:

1. Lay the plants flat between papers; then place them between two smooth plates of iron screwed together at the corners: in this state they are to be committed to a baker's oven for two hours. After being taken out, they must be rubbed over with a mixture, consisting of equal parts of brandy and vinegar, then pasted down on paper with a solution of gum-tragacanth in water, after which they are to be laid in a book, where they will adhere, and retain ther original freshness. The following method is however more simple.

2. Flatten the plant by passing a common smoothing-iron over the papers between which it is placed, and dry it slowly in a sand-heat. For this purpose the cold sand ought to be spread evenly, the smoothened plant laid gently on it, and sand sifted over so as to form a thick bed; the fire is then to be kindled, and the whole process carefully watched, till the plant is gradually and perfectly dried. Thus the colour of the tenderest herb, may be preserved, and the most delicate flowers retain all their pristine beauty.

3. Another and far more complete method was suggested by the ingenious Mr. Whately. He directs those who intend to follow his plan, previously to procure—1. A strong oak-box of the same size and shape as those employed for packing up tin plates; 2. a quantity of fine sifted sand, sufficient to fill the box; 3, a considerable number of pieces of pliant paper, from one to four inches square; and 4. some small flat leaden weights, and a few small bound books.

The plant is first to be cleared from the soil as well as the decayed leaves, and then laid on the inside of one of the leaves of a sheet of common cap-paper. The upper leaves and flowers are next to be covered, when expanded, by pieces of the prepared paper, and one or two of the leaden weights placed on them. The remainder of the plant is now to be treated in a similar manner.

The weights ought next to be gently removed, and the other leaf of the sheet of paper folded over the opposite one so as to contain the loose pieces of paper and plants between them. A book or two is now to be applied to the outside of the paper till the intended number of plants is thus prepared; when a box is to be filled with sand to the depth of an inch, one of the plants put in, and covered with sand sufficient to prevent the form of the plant from varying. The other plants may then be placed in succession, and likewise covered with a layer of sand, one inch thick between each; after which the whole is to be gently pressed down in a greater or less degree, according to the tenderness or firmness of the plants.

The box is next to be carefully placed before a fire, one side being occasionally a little raised, as may be most convenient; the sides being alternately presented to the fire two or three times in the day, or the whole may be put into an oven gently heated. In the course of two or three days the plants will be perfectly dry, when the sand ought to be taken out and put into another box: the plants should likewise be removed to a sheet of writing paper.

HOSPITALERS, an order of religious knights, now known by the title of knights of Malta.

HOT-BEDS, in gardening, beds made with fresh horse-dung, or tanner's bark, and covered with glasses to defend them from cold winds.

According to the quantity and quality of the materals put together for hot beds, the heat will be proportioned as to strength and duration; and by a judicious use in making, and the management afterwards, many advantages may be obtained from them. The great point is, to suit the degree of heat to the nature of the different

plants to be cultivated, that they may have neither more nor less than is necessary to promote a regular vegetation.

Two errors are common in the use of hot-beds, sowing or placing in the same bed things of a very different nature, as to the climate they grow best in, and forcing with too much heat even the tenderest. Though it may not answer our often too hasty views, the heat of a bed had better be slack than otherwise. A strong hot-bed that ought at least to be made a fortnight before it is used, is sometimes furnished by impatience in a few days, and various ill consequences follow, which naturally frustrate expectation.

The place where hot-beds are worked should be open to the full sun, catching it as early as possible in the morning, and having it as long as can be in the evening; and if not naturally sheltered, it should be screened from the north and nort-east winds by a bordered fence or rather one of reeds, as from a solid fence the wind reverberates; but straw or flake-hurdles set endwise may do. A screen of some sort (and a close-clipt hedge is as good as any) not only protects the inclosure from the harsher winds, and confines the warm air, but keeps a rather unsightly work from view, and straws from blowing about, the litter of which is so disagreeable.

Working of the dung is necessary previous to the making of a hot-bed, *i. e.* it should be thrown together on an heap, in a conical form; and when it has taken a thorough heat, and has been smoking or sweating for two or three days, it should be turned over, moving the outside in, or mixing the colder parts with the hot. When it has taken heat again for two or three days, give it a second turn as before, and having lain the same time, it will be in proper order for making a good lasting bed with a steady heat. If in haste, it may be made into a bed after the first heating; but it will be better for shifting again, or even a third time. When dung is ready before wanted, keep turning it over, lest it should be too much spent. It will be proper to begin to work fresh dung a week or ten days before it is used; but if the dung is not fresh, it is only necessary to throw it together for once heating.

The size of a hot-bed, as to length and breadth, is of course to be according to the frame; and the height of it according to the season and the degree of heat requisite to the nature of the plant to be cultivated. In a dry soil, a bed may be sunk in the ground from six inches to a foot, to make it more convenient to get at and manage. But beds made forward in the season should rather be on the surface, for the sake of being able to add stronger linings, &c.

In case of an insufficient quantity of good horse-dung, that of cows, oxen, or pigs, if it is strawy, and not too wet, may be mixed with it, in the proportion of one-fourth or more, especially in an advanced part of the season, or to cultivate things that are only forcing, and do not naturally require heat.

When the season is pretty much advanced, hot-beds may be made of grass mowings (as from an orchard) and weeds, which is a common practice in the cyder countries. These heats, however, are often too violent, and last not long; yet they may be lined with the same materials if done in time, otherwise if a green hot-bed gets greatly cool, it will not be recovered. A grass bed may be used as soon as warm, but let it not be overweighted by putting on heavy frames, or more mould than necessary. It should rather be worked with hand-glasses or oiled paper covers.

Hot-beds are sometimes made of the refuse bark of a tanner's yard, and also of oak-leaves; but these must have walled pits for them of a large size, and are seldom used but in hot-houses. A bark-bed properly made, and managed by forking up at two or three month's end, &c. will hold a fair, moderate, and steady heat four, five, or six months.

To decrease the heat of a bed, several holes may be made in it, by thrusting an iron bar, or a thick smooth sharp-pointed stake, up to the middle, which holes are to be close stopt again with dung or hay when the heat is sufficiently abated.

The uses to which hot-beds may be applied are various, but chiefly for the cultivation of cucumbers and melons. At the spring of the year, hot-beds are commonly made use of for forcing crops of several vegetables, as radishes, carrots, cauliflowers, lettuces, potatoes, turneps, kidney-beans, parslane, tarragon, small sallading, &c. Fruits of several sorts, strawberries, raspberries, &c. are sometimes brought forward by dung heat; as also various shrubs and flowers, by means of forcing-frames. Tender annuals, as balsams and other flowers that necessarily require heat to bring them up, and the less tender, and some even of the hardy sorts, are also cultivated on hot-beds, or by other assistance from dung, to produce an earlier blow than could otherwise be had.

Hot-house, in salt-making, the place where they dry the salt, when taken out of the boiling-pan. It is situated near the furnace, which, by means of funnels or tubes, conveys the heat into it.

Hot-house, in gardening, an erection intended for the culture of the tender exotics of tropical climates. It is usually built lower than a greenhouse, with double flues, and a pit in the middle for tanner's bark, in which, as in a kind of hot-bed, the pots containing the plants are to be plunged. A hot-house should be kept at a regular heat, seldom less than 70°; and when the weather becomes about 10° below that extremity, the fires may be left off. The tan should be renewed twice a year, in spring and autumn; and care must be taken not to plunge the plants in it till the heat is risen to a proper degree.

The ingenious Dr. Anderson, so well known for his labours in agriculture, has lately constructed a hot-house to be kept warm by air chiefly warmed by the heat of the sun. It is entirely of glass, and the upper part is a close chamber to contain the heated air, which is let into the house by a valve. In the winter the chamber is heated by a lamp, and the warm air is admitted in the same manner as that which is warmed by the sun. The house is also moveable; but for further details we must refer to the doctor's Agricultural Recreations.

HOTCH-pot, in law, is used for mixing of lands given in marriage with other lands in fee which fall by descent; as where a man possessed of thirty acres of land has issue only two daughters, and after his having given with one of them ten acres in marriage, he dies possessed of the other twenty. Here she that is thus married, in order to gain her share of the rest of the land, must put

her part given in marriage in hotch-pot; that is, she must refuse to take the sole profits of her lands, and cause it to be mingled with the other, so that an equal division may be made of the whole between her and her sister; by which means, instead of only her ten acres, she has fifteen.

HOVENIA, a genus of the class and order pentandria monogynia. The petals are five, convoluted; stigma trifid; capsule three-celled, three-valved. There is one species, a shrub of Japan.

HOVERING. Ships of 50 tons, laden with customable or prohibited goods, hovering on the coasts of this kingdom, within the limits of any port (and not proceeding from foreign parts), may be entered by officers of the customs, who are to take an account of the lading, and to demand and take a security from the master, by his bond to his majesty, in such sum of money as shall be treble the value of such foreign goods then on board; that such ship shall proceed (as soon as wind and weather and the condition of the ship will permit) on her voyage to foreign parts, and shall land the goods in some foreign port; the master refusing to enter into such bond on demand, or who having given bond, shall not proceed on such voyage (unless otherwise suffered to make a longer stay by the collector or other principal officer of such port where the vessel shall be, not exceeding 20 days); in either of the said cases, all the foreign goods may be taken out by the customhouse-officers, by direction of the collector, and properly secured; and if they are customable, the duties shall be paid; and if prohibited, they shall be forfeited.

The officers of the customs may prosecute the same, as also the ship, if liable to condemnation. 3 Geo. III. c. 21.

Commanders of men of war, and customhouse-officers, may compel ships of 50 tons, or under, hovering within two leagues of shore, to come into port. 6 Geo. I. c. 21.

If any ship or vessel shall be found at anchor, or hovering within eight leagues of the coast (except between the North Foreland and Beachy Head), unless by distress of weather, having on board foreign spirits, in any vessel or cask which shall not contain 60 gallons at least, or any wine in casks (provided such vessel shall have wine on board), shall not exceed 60 tons burthen, or six pounds weight of tea, or 20 pounds weight of coffee, or any goods whatever liable to forfeiture upon importation, that such goods, with the ship and furniture, shall be forfeited; spirits for the use of seamen, not exceeding two gallons per man, excepted. 42 Geo. III. c. 82.

HOUND. See CANIS.

HOUR, *hora*, in chronology, an aliquot part of a natural day, usually a 24th, sometimes a 12th. See ASTRONOMY, GEOGRAPHY, &c.

There are different hours used by chronologers, astronomers, dialists, &c. Sometimes hours are divided into equal and unequal. Equal hours are the 24th part of a day and night precisely, that is, the time wherein 15 degrees of the equator mount above the horizon. These are also called equinoctial hours, because they are measured on the equinoctial; and astronomical, because used by astronomers. They are also differently denominated according to the manner of accounting them in different countries. Astronomical hours are equal hours, reckoned from noon or mid-day, in a continued series of twenty-four. Babylonish hours are equal hours reckoned in the same manner from sun-rise. The Italian hours are also equal hours, reckoned in the same manner too, from sun-setting. European hours are also equal hours, reckoned from midnight; 12 from thence to noon, and 12 more from noon to midnight. Jewish, or planetary, or ancient hours, are the twelfth part of the artificial day and night, each being divided into 12 equal parts. Hence, as it is only in the time of the equinoxes that the artificial day is equal to the night, it is then only that the hours of the day are equal to those of the night. At other times they will be always either increasing or decreasing: and they will be the more or less unequal according to the obliquity of the sphere.

HOUSE. Every man's house is as his castle, as well to defend him against injuries, as for his repose.

Upon recovery in any real action or ejectment, the sheriff may break the house and deliver seisin, &c. to the plaintiff, the writ being habere facias seisinam, or possessionem; and after judgment it is not the house of the defendant in right and judgment of the law.

In all cases where the king is party, the sheriff, if no door is open, may break the party's house to take him, or to execute other process of the king, if he cannot otherwise enter; but he ought first to signify the cause of his coming, and request the door to be opened: and this appears by the statute Westm. 1, 17, which is only in affirmance of the common law; and without default in the owner, the law will not suffer an house to be broken.

In all cases where the door is open, the sheriff may enter and make execution at the suit of any subject, either of body or goods; but otherwise where the door is shut, there he cannot break it to execute process at the suit of a subject.

Though an house is a castle for the owner himself and his family, and his own goods, &c. yet it is no protection for a stranger flying thither, or the goods of such a one, to prevent lawful execution; and therefore in such case, after request to enter, and denial, the sheriff may break the house. 5 Rep. 91.

If a person authorized to arrest another who is sheltered in an house, is denied quietly to enter into it, in order to take him, it seems generally to be agreed, that he may justify the breaking open of the doors upon a capias from the king's bench or chancery, to compel a man to find sureties for the peace or good behaviour, or even upon a warrant from a justice of the peace for such person.

So where one known to have committed treason, is pursued either with or without a warrant, by a constable or private person.

So where an affray is made in an house in the view or hearing of a constable; or where those who have made an affray in his presence fly to an house, and are immediately pursued by him, and he is not suffered to enter in order to suppress the affray in the first case, or to apprehend the affrayers in either case. 2 Haw. 86, 87.

A man ought so to use his house as not to damnify his neighbour: and a man may compel another to repair his house in several cases by the writ de domo reparanda. 1 Salk. 360.

If a man builds his house so close to mine, that his roof overhangs my roof, and throws the water of his

roof upon mine, this is a nuisance for which an action will lie.

But depriving one of a mere matter of pleasure, as of a fine prospect, by building a wall or the like; this, as it abridges nothing really convenient or necessary, is no injury to the sufferer, and is therefore not an actionable nuisance. 3 Black. 217.

HOUSEHOLD, the whole of a family considered collectively, including the mistress, children, and servants: but the household of a sovereign prince includes only the officers and domestics belonging to his palace.

The principal officers of his majesty's household are, the lord steward, lord chamberlain of the household, the groom of the stole, the master of the great wardrobe, and the master of the horse. The civil government of the king's house is under the care of the lord steward of the king's household, who, as he is the chief officer, all his commands are observed and obeyed. His authority extends over all the other officers and servants, except those of his majesty's chapel, chamber, and stable; and he is the judge of all crimes committed either within the court or the verge. Under him are the treasurer of the household, the comptroller, cofferer, the master of the household, the clerks of the green cloth, and the officers and servants belonging to the accounting-house, the marshalsea, the verge, the king's kitchen, the household kitchen, the acatery, bakehouse, pantry, buttery, cellar, pastry, &c. Next to the lord steward is the lord chamberlain of the household, who has under him the vice-chamberlain, the treasurer, and comptroller of the chamber, 12 of whom wait quarterly, and two of them lie every night in the privy chamber; the gentleman usher, the grooms of the great chamber, the pages of the presence chamber; the mace-bearers, cup-bearers, carvers, musicians, &c.

The groom of the stole has under him the eleven other lords of the bed-chamber, who wait weekly in the bed-chamber, and by turns lie there a-nights on a pallat-bed; and also the grooms of the bed-chamber, the pages of the bed-chamber and back stairs, &c.

The master or keeper of the great wardrobe has under him a deputy, comptroller, clerk of the robes, brusher, &c. and a number of tradesmen and artificers, who are all sworn servants to the king.

The master of the horse has under his command the equerries, pages, footmen, grooms, coachmen, farriers, saddlers, and all the other officers and tradesmen employed in his majesty's stables.

Next to the civil list of the king's court is the military, consisting of the band of gentlemen pensioners, the yeomen of the guard, and the troops of the household; of which the two first guard the king above stairs.

When the king dines in public, he is waited upon at table by his majesty's cup bearers, carvers, and gentlemen sewers, the musicians playing all the time. The dinner is brought up by the yeomen of the guard, and the gentlemen sewers set the dishes in order. The carvers cut for the king, and the cup-bearers serve him the drink with one knee on the ground, after he has first tasted it in the cover.

HOUSTONIA, a genus of the monogynia order, in the tetrandria class of plants, and in the natural method ranking under the 47th order, stellatæ. The corolla is monopetalous and funnel-shaped; the capsule bilocular, dispermous, superior. There are two species, shrubs of America.

HOUTTYNIA, a genus of the class and order polyandria polygynia. The calyx is four-leaved; corolla none, stamina mixed with the pistils, seven about each germ. There is one species, an herb of the East Indies, having the habit of a polygonum.

HUDSONIA, a genus of the monogynia order, in the dodecandria class of plants. There is no corolla: the calyx is pentaphyllous and tubular; there are 15 stamina; the capsule is unilocular, trivalvular, and trispermous. There is one species, a shrub of Virginia.

HUE AND CRY, is the ancient common law process after felons, and such as have dangerously wounded any person, or assaulted any one with an intent to rob him; and it has received great countenance and authority by several acts of parliament. In any of which cases, the party grieved, or any other, may resort to the constable of the vill; and, 1. give him such reasonable assurances thereof as the nature of the case will bear: 2. if he knows the name of him that did it, he must tell the constable the same: 3. if he knows it not, but can describe him, he must describe him, his person, or his habit, or his house or such circumstances as he knows, which may conduce to the discovery: 4. if the thing is done in the night, so that he knows none of these circumstances, he must mention the number of persons, or the way they took: 5. if none of all these can be discovered, as where a robbery, or burglary, or other felony, is committed in the night, yet they are to acquaint the constable with the fact, and desire him to search his town for suspected persons, and to make hue and cry after such as may probably be suspected, as being persons vagrant in the same night; for many circumstances may happen to be useful for discovering a malefactor, which cannot at first be found out.

For the levying of hue and cry, although it is a good course to have a justice's warrant, where time will permit, in order to prevent causeless hue and cry; yet it is not necessary nor always convenient, for the felon may escape before the warrant is obtained. And upon hue and cry levied against any person; or where any hue and cry comes to a constable, whether the person is certain or uncertain, the constable may search suspected places within his vill, for the apprehending of a felon. And if the person against whom the hue and cry is raised, is not found in the constablewick, then the constable, and also every officer to whom the hue and cry shall afterwards come, ought to give notice to every town round about him, and to one next town only; and so from one constable to another, until the offender is found, or till they come to the sea-side. And this was the law before the conquest.

And in such cases it is needful to give notice in writing to the pursuers of the thing stolen, and of the colour and marks thereof, as also to describe the person of the felon, his apparel, horse, or the like, and which way he is gone, if it may be: but if the person that did the fact is neither known nor describable by his person, clothes, or the like, yet such a hue and cry is good, and must be pursued, though no person certain can be named or described. 2 H. H. 100. 103.

HUER, a name given to certain fountains in Iceland, of a most extraordinary nature, forming at times jets d'eaux of scalding water 94 feet high and 30 in diameter. They arise out of cylindrical tubes of unknown depths. Near the surface they expand into apertures of a funnel shape, and the mouths spread into a large extent of stalactical matter, formed of successive scaly concentric undulations. The playing of these stupendous spouts is foretold by noises roaring like the cataract of of Niagara. The cylinder begins to fill: it rises gradually to the surface, and as gradually increases its height, smoking amazingly, and flinging up great stones. After attaining its greatest height, it gradually sinks till it totally disappears. Boiling jets d'eaux and boiling springs are frequent in most parts of the island; and in many parts they are commonly applied to the culinary uses of the natives. The most capital is that which is called geyer or geyser, in a plain rising into small hills, and in the midst of an amphitheatre, bounded by the most magnificent and various-shaped icy mountains, among which the three-headed Hecla soars pre-eminent. These huers are not confined to the land; they rise in the very sea, and form scalding fountains amidst the waves. Their distance from the land is unknown; but the new volcanic isle, twelve miles off the point of Reickness, emitting fire and smoke, proves that the subterraneous fires and waters extend to that space; for those awful effects arise from the united fury of these two elements.

HUGONIA, a genus of the decandria order, in the monadelphia class of plants, and in the natural method ranking with those of which the order is doubtful. The corolla is pentapetalous; the fruit is a plum with a striated kernel. There is one species, a tree of the East Indies.

HUGUENOTS, a name given by way of contempt to the protestants of France. The name had its rise in the year 1560; but authors are not agreed as to its origin. The most plausible opinion, however, is that of Pasquier, who observes, that at Tours, the place where they were first thus denominated, the people had a notion that an apparition or hobgoblin, called king Hugon, strolled about the streets in the night-time; whence as those of the reformed religion met chiefly in the night to pray, &c. they called them Huguenots, that is, the disciples of king Hugon.

HULL, in the sea language, is the main body of a ship, without either masts, yards, sails, or rigging. Thus to strike a hull in a storm is to take in her sails, and to lash the helm on the lee-side of the ship; and to hull or lie a hull, is said of a ship whose sails are thus taken in, and helm lashed a-lee.

HUMERUS. See ANATOMY.

HUMERUS, *luxation of the*. See SURGERY.

HUMMING-BIRD. See TROCHILUS.

HUMULUS, *the hop*, a genus of the pentandria order, in the diœcia class of plants, and in the natural method ranking under the 53d order, scabridæ. The male calyx is pentaphyllous; there is no corolla: the female calyx is monophyllous, patent obliquely, and entire; there is no corolla, but two styles, and one seed within the calyx, the latter consisting of one large leaf. There is only one species, viz. the lupulus, which is sometimes found wild in hedges near houses and gardens, but probably is not indigenous. The stalk is weak and climbing; it creeps up the support in a spiral, ascending always from the right hand to the left.

Hops are said to have been first brought into England from the Netherlands in the year 1524. They are first mentioned in the English statute-book in the year 1552, viz. in the 5th and 6th Edw. VI. cap. 5.: and by an act of parliament of the first year of king James I. anno 1603, cap. 18. it appears that hops were then produced in abundance in England. The hop being a plant of great importance, we shall consider what relates to the culture and management of it under distinct heads.

Of soil. As for the choice of soil, the hop-planters esteem the richest and strongest ground the most proper; and if it is rocky within two or three feet of the surface, the hops will prosper well; but they will by no means thrive on a stiff clay or spongy wet land.

The Kentish planters account new land best for hops; they plant their hop gardens with apple-trees at a large distance, and with cherry-trees between; and when the land has done its best for hops, which they reckon it will in about ten years, the trees may begin to bear.

To plant hops. In the winter time provide your soil and manure for the hop-ground against the following spring. If the dung is rotten, mix it with two or three parts of common earth, and let it incorporate together till you have occasion to make use of it in making your hop-hills; but if it is new dung, then let it be mixed as before till the spring in the next year, for new dung is very injurious to hops.

Hops require to be planted in a situation so open as that the air may freely pass round and between them, to dry up and dissipate the moisture, whereby they will not be so subject to fire-blasts, which often destroy the middles of large plantations, while the outsides remain unhurt.

The hills should be eight or nine feet asunder, that the air may freely pass between them. If the ground is intended to be ploughed with horses between the hills, it will be best to plant them in squares chequerwise; but if the ground is so small that it may be done with the breast-plough or spade, the holes should be ranged in a quincunx form. Which way soever you make use of, a stake should be stuck down at all the places where the hills are to be made.

Persons ought to be very curious in the choice of the plants as to the kind of hop; for if the hop garden is planted with a mixture of several sorts of hops that ripen at several times, it will cause a great deal of trouble, and be a great detriment to the owner. The two best sorts are the white and the grey bind; the latter is a large square hop, more hardy, and is the more plentiful bearer, and ripens later than the former. There is another sort of the white bind, which ripens a week or ten days before the common; but this is tenderer, and a less plentiful bearer; but it has this advantage, that it comes first to market.

If there is a sort of hop you value, and would increase plants and sets from, the superfluous binds may be laid down when the hops are tied, cutting off the tops, and burying them in the hill; or when the hops are dressed, all the cuttings may be saved; for almost every part will grow, and become a good set the next spring.

As to the seasons of planting hops, the Kentish planters approve the months of October and March. The most usual time, however, of procuring them is in March, when the hops are cut and dressed.

As to the manner of planting the sets, there should be five good sets planted in every hill, one in the middle, and the rest round about sloping. Let them be pressed close with the hand, and covered with fine earth, and a stick should be placed on each side the hill to secure it.

Dressing. As to the dressing of the hops, when the hop-ground is dug in January or February, the earth about the hills, and very near them, ought to be taken away with a spade, that you may come the more conveniently at the stock to cut it. About the end of February, if the hops were planted the spring before, or if the ground is weak, they ought to be dressed in dry weather; but else, if the ground is strong and in perfection, the middle of March will be a good time; and the latter end of March, if it is apt to produce over-rank binds, or the beginning of April may be soon enough. Then having with an iron picker cleared away all the earth out of the hills, so as to clear the stock to the principal roots, with a sharp knife you must cut off all the shoots which grew up with the binds the last year; and also all the young suckers, that none be left to run in the alley, and weaken the hill. It will be proper to cut one part of the stock lower than the other, and also to cut that part low that was left highest the preceding year. In dressing those hops that have been planted the year before, you ought to cut off both the dead tops and the young suckers which have sprung up from the sets, and also to cover the stocks with fine earth a finger's length in thickness.

The poling. About the middle of April the hops are to be poled, when the shoots begin to sprout up; the poles must be set to the hills deep into the ground, with a square iron picker or crow, that they may the better endure the winds; three poles are sufficient for one hill. These should be placed as near the hill as may be, with their bending tops turned outwards from the hill to prevent the binds from entangling; and a space between two poles ought to be left open to the south to admit the sunbeams.

The tying. As to the tying of hops, the buds that do not clasp of themselves to the nearest pole when they are grown to three or four feet high, must be guided to it by the hand, turning them to the sun, whose course they will always follow. They must be bound with withered rushes, but not so close as to hinder them from climbing up the pole. This you must continue to do till all the poles are furnished with binds, of which two or three are enough for a pole; and all the sprouts and binds that you have no occasion for, are to be plucked up; but if the ground is young, then none of these useless binds should be plucked up, but should be wrapped up together in the middle of the hill.

Gathering. About the beginning of July hops begin to blow, and will be ready to gather about Bartholomew-tide. A judgment may be made of their ripeness by their strong scent, their hardness, and the brownish colour of their seed. When by these tokens they appear to be ripe, they must be picked with all the expedition possible; for if at this time a storm of wind should come, it would do them great damage by breaking the branches, and bruising and discolouring the hops; and it is very well known that hops, being picked green and bright, will sell for a third more than those which are discoloured and brown.

The most convenient way of picking them is into a long square frame of wood, called a bin, with a cloth hanging on tenter-hooks within it, to receive the hops as they are picked.

The hops must be picked very clean, *i. e.* free from leaves and stalks; and, as there shall be occasion, two or three times in a day the bin must be emptied into a hop-bag made of coarse linen cloth, and carried immediately to the oast or kiln in order to be dried; for if they should be long in the bin or bag, they will be apt to heat and be discoloured. If the weather is hot, there should no more poles be drawn than can be picked in an hour, and they should be gathered in fair weather, if it can be, and when the hops are dry; this will save some expense in firing, and preserve their colour better when they are dried.

Drying. The best method of drying hops is with charcoal on an oast or kiln, covered with hair-cloth, of the same form and fashion that is used for drying malt. There is no need to give any particular directions for making these, since every carpenter or brick-layer in those countries where hops grow, or malt is made, knows how to build them. The kiln ought to be square, and may be of ten, twelve, fourteen, or sixteen feet over at the top, where the hops are laid, as your plantation requires, and your room will allow. There ought to be a due proportion between the height and breadth of the kiln and the beguels of the steddle where the fire is kept, viz. if the kiln is twelve feet square on the top, it ought to be nine feet high from the fire, and the steddle ought to be six feet and a half square, and so proportionable in other dimensions.

The hops must be spread even upon the oast a foot thick or more, if the depth of the curb will allow it; but care is to be taken not to overload the oast if the hops are green or wet. The oast ought to be first warmed with a fire before the hops are laid on, and then an even steady fire must be kept under them; it must not be too fierce at first, lest it scorch the hops, nor must it be suffered to sink or slacken, but rather be increased till the hops are nearly dried, lest the moisture or sweat which the fire has raised fall back or discolour them. When they have lain about nine hours they must be turned, and in two or three hours more they may be taken off the oast. It may be known when they are well dried by the brittleness of the stalks and the easy falling off the hop-leaves.

Bagging. As soon as the hops are taken off the kiln, lay them in a room for three weeks or a month to cool, give, and toughen; for if they are bagged immediately they will powder, but if they lie a while (and the longer they lie the better, provided they are covered close with blankets to secure them from the air) they may be bagged with more safety, as not being liable to be broken to powder in treading; and this will make them bear treading the better, and the harder they are trodden the better they will keep.

Laws relating to hops. By 9 Anne, cap. 121, an additional duty of 3*d.* a pound is laid on all hops imported, over and above all other duties; and hops landed before

entry and payment of duty, or without warrant for landing, shall be forfeited and burnt; the ship also shall be forfeited, and the person concerned in importing or landing shall forfeit 5*l.* a hundred weight, 7 Geo. II. cap. 19. By 9 Anne, cap. 12, there shall be paid a duty of 1*d.* for every pound of hops grown in Great Britain, and made fit for use, within six months after they are cured and bagged; and hop-grounds are required to be entered on pain of 40*s.* an acre. Places of curing and keeping are also to be entered on pain of 50*l.* which may be visited by an officer at any time without obstruction, under the penalty of 20*l.* All hops shall, within six weeks after gathering, be brought to such places to be cured and bagged, on pain of 5*s.* a pound. The re-bagging of foreign hops in British bagging for sale or exportation, incurs a forfeiture of 10*l.* a hundred weight; and defrauding the king of his duty by using twice or oftener the same bag, with the officer's mark upon it, is liable to a penalty of 40*l.* The removal of hops before they have been bagged and weighed, incurs a penalty of 50*l.* Concealment of hops subjects to the forfeiture of 20*l.* and the concealed hops; and any person who shall privately convey away any hops with intent to defraud the king and owner, shall forfeit 5*s.* a pound. And the duties are required to be paid within six months after curing, bagging, and weighing, on pain of double duty, two-thirds to the king, and one-third to the informer. No common brewer shall use any bitter ingredient instead of hops, on pain of 20*l.* Hops which have paid the duty may be exported to Ireland; but by 6 Geo. II. cap. 11, there shall be no drawback; and by 7 Geo. II. cap. 19. no foreign hops shall be landed in Ireland. Notice of bagging and weighing shall be sent in writing to the officer, on pain of 50*l.* 6 Geo. cap. 21. And by 14 Geo. III. cap. 68. the officer shall, on pain of 5*l.* weigh the bags or pockets, and mark on them the true weight or tare, the planter's name and place of abode, and the date of the year in which such hops were grown; and the altering or forging, or oblitering such mark, incurs a forfeiture of 10*l.* The owners of hops shall keep at their oasts, &c. just weights and scales, and permit the officer to use them, on pain of 20*l.* 6 Geo. cap. 21. And by 10 Geo. III. cap. 44. a penalty of 100*l.* is inflicted for false scales and weights. The owners are allowed to use casks instead of bags, under the same regulations, 6 Geo. II. cap. 21. If any person shall mix with hops any drug to alter the colour or scent, he shall forfeit 5*l.* a hundred weight. If any person shall unlawfully and malicious cut hop-binds growing on poles in any plantation he shall be guilty of felony without benefit of clergy. 6 Geo. II. cap. 37. By a late act, five per cent. is added to the duties on hops.

HUNDRED. In the time of king Alfred the kingdom was in gross, and then divided into counties and hundreds, and all persons came within one hundred or other.

By stat. 2 Ed. III. c. 12. it was enacted, that all hundreds and wapentakes granted by the king, shall be annexed to the king, and not severed. And by 14 Ed. III. c. 9. that all should be annexed, and the sheriff should have power to put in bailiffs, for which he will answer, and no more shall be granted for the future.

Hundreds are not answerable to persons who are robbed travelling on a Sunday. 29 Car. II. c. 7.

Hundreds are liable to penalty on exportation of wool. 7 and 8 W. III. c. 28.

Hundreds are liable to damages sustained by pulling down buildings. 1 Geo. I. c. 5.

Hundreds are liable for damages by killing cattle, cutting down trees, burning houses, &c. 9 Geo. I. c. 22, and 29 Geo. II. c. 36.

Hundreds are liable for damages incurred by destroying turnpikes or works on navigable rivers. 8 Geo. II. c. 20.

By cutting hop-binds, 10 Geo. II. c. 32. By destroying corn to prevent exportation, 11 Geo. II. c. 22. By wounding officers of the customs, 19 Geo. II. c. 34; or by destroying wood, &c. 29 Geo. II. c. 36.

All monies recovered against the hundred to be levied by a rate. 22 Geo. II. c. 46.

HUNGARY-WATER, a distilled water, so denominated from a queen of Hungary, for whose use it was first prepared.

Quincy gives the following directions for making it: Take of fresh gathered flowers of rosemary two pounds, rectified spirits of wine two quarts; put them together, and distil them immediately in balneo.

HURA, a genus of the monadelphia order, in the monœcia class of plants, and in the natural method ranking under the 38th order, tricoccæ. The amentum of the male is imbricated, the perianthium truncated: there is no corolla; the filaments are cylindrical, peltated on top, and surrounded with numerous or double antheræ. The female has neither calyx nor corolla; the style is funnel-shaped; the stigma cleft in twelve parts; the capsule is twelve-celled, with a single seed in each cell. There is but one species, viz. the crepitans, a native of the West Indies. It rises with a soft ligneous stem to the height of 24 feet, dividing into many branches. After the flower, the germen swells, and becomes a round compressed ligneous capsule, having 12 deep furrows, each being a distinct cell, containing one large round compressed seed. When the pods are ripe, they burst with violence, and throw out their seeds to a considerable distance. It is propagated by seeds raised on a hot-bed; and the plants must be constantly kept in a stove. The kernels are said to be purgative, and sometimes emetic.

HURDLES, in fortification, twigs of willows or osiers interwoven close together, sustained by long stakes, and usually laden with earth. See FORTIFICATION.

HURRICANE, a furious storm owing to a contrariety of winds. See WIND.

Hurricanes are frequent in the West Indies, where they make terrible ravages, by rooting up trees, destroying houses and shipping, and even whole plantations.

These dreadful convulsions of nature, Dr. Perkins, of Boston, supposes to be caused by some occasional obstruction in the usual and natural progress of the equatorial trade winds. The reason he assigns for this conjecture is, the more than usual calm which commonly precedes them. In the natural course of the trade winds, the air rises up in the line, and passes off towards the poles, and, in the more contracted degrees of the higher latitudes, takes the course of the west trade-winds, so that could their ascent be prevented through the whole circle of the zone, there would be no more west winds in those latitudes than in any other. Very

violent rains and cold, however, tend to check the ascent of air out of this circle, rather causing it to descend. Great clouds of vapour generate cold and wet, while rain beats down the air; and as these prevent the rising of the air out of the line, so they hinder its usual progress from the tropics on both sides; hence the calms which usually precede hurricanes. Calms, in these tropical regions, are caused by the ascent of the air into the higher part of the atmosphere, instead of its remaining near the line: the accumulation of air above then becomes heavier by the cold which it meets in those regions, and descends into the more rarefied region below. These heavy gales, therefore, will continue to descend till the upper regions are entirely exonerated.

HUSBAND AND WIFE, usually called baron and feme, are one person in law: that is, the very being or legal existence of the woman is suspended during the marriage, or at least is incorporated and consolidated into that of the husband, under whose wing, protection and cover she performs every thing. She is therefore called in our law French, a *feme covert*, that is, under the protection and influence of her husband, her baron or lord; and her condition during her marriage is called her coverture.

A man cannot grant lands to his wife during her coverture, nor any estate or interest to her, nor enter into covenent with her. But he may by his deed covenant with others for her use, as for her jointure, or the like; and he may give to her by devise or will, because the devise or will does not take effect till after his death. 1 Inst. 112.

All deeds executed by the wife, and acts done by her during her coverture, are void, except a fine, or the like matter of record, in which case she must be solely and secretly examined, that it may be known whether or no her act is voluntary. 1 Black. 444.

A wife is so much favoured in respect of that power and authority which her husband has over her, that she shall not suffer any punishment for committing a bare theft in company with, or by coercion of her husband. But if she commits a theft of her own voluntary act, or by the bare command of her husband, or is guilty of treason, murder, or robbery, in company with or by coercion of her husband, she is punishable as much as if she was sole; because of the odiousness and dangerous consequences of these crimes. 1 Haw. 2.

By marriage the husband has power over his wife's person; and the courts of law still permit an husband to restrain a wife of her liberty, in case of any gross misbehaviour. But if he threatens to kill her, &c. she may make him find surety of the peace, by suing a writ of supplicavit out of chancery, or by preferring articles of the peace against him in the court of king's bench, or she may apply to the spiritual court for a divorce propter sævitatem.

The husband by marriage obtains a freehold in right of his wife, if he takes a woman to wife that is seized of a freehold; and he may make a lease thereof for 21 years, or three lives, if it is made according to the statute. 32 Hen. VIII. c. 28.

The husband also gains a chattel real, as a term for years, to dispose of if he pleases by grant or lease in her life-time, or by surviving her: otherwise it remains with the wife. And upon execution for the husband's debt, the sheriff may sell the term during the life of the wife. 1 Inst. 351.

The husband also by the marriage has an absolute gift of all chattels personal in possession of the wife in her own right, whether he survives her or not. But if these chattels personal are choses in action, that is, things to be sued for by action, as debts by obligation, contract, or the like, the husband shall not have them, unless he and his wife recover them. 1 Inst. 351.

By custom in London, a wife may carry on a separate trade; and as such, is liable to the statutes of bankruptcy with respect to the goods in such separate trade, with which the husband cannot intermeddle. Burr. 1776.

If the wife is indebted before marriage, the husband is bound afterwards to pay the debt, living with the wife; for he has adopted her and her circumstances together. 1 Black. 143. But if the wife dies, the husband shall not be charged for the debt of his wife after her death, if the creditor of the wife does not get judgment during the coverture. 9 Co. 72.

The husband is bound to provide his wife necessaries; and if she contracts for them, he is obliged to pay for the same; but for any thing besides necessaries, he is not chargeable.

And also if a wife elopes, and lives with another man, the husband is not chargeable even for necessaries: at least if the person who furnishes them is sufficiently apprized of her elopement. 1 Black. 442.

A man having issue by his wife born alive, shall be tenant by the courtesy of all the lands in fee simple, or fee tail general, of which she shall die seized. Litt. 52.

And after her death he shall have all chattels real: as the term of the wife, or a lease for years of the wife, and all other chattels in possession; and also, all such as are of a mixed nature (partly in possession and partly in action), as rents in arrear, incurred before the marriage or after: but things merely in action, as of a bond or obligation to the wife, he can only claim them as administrator to his wife, if he survives her. Wood. b. 1. c. 6.

If the wife survives the husband, she shall have for her dower the third part of all his freehold lands: so she shall have her term for years again, if he has not altered the property during his life: so also she shall have again all other chattels real and mixed: and so things in action, as debts, shall remain to her, if they were not received during the marriage. Id.

But if she elopes from her husband, and goes away with her adulterer, she shall lose her dower, unless her husband had willingly, without coercion ecclesiastical, been reconciled to her, and permitted her to cohabit with him. 1 Inst. 32.

HUSBAND LAND, a term used in Scotland for a portion of land containing six acres of sock and scythe land, that is, of land that may be tilled with a plough and mown with a scythe.

HUSBANDRY, in the general sense of the word, comprehends the whole practice of agriculture; in which we have to consider the nature of the soils we meet with, on and near the surface of the earth. The methods of correcting those which are unfavourable to the production of useful vegetables; the improvement of such as are deteriorated by over-cropping; such implements as

are fittest for facilitating the operations of agriculture; the means and powers best adapted for such purposes; the cattle and live stock most profitable to man, whether for labour or more immediate use as food; the grass, grain, roots, and pulse, most beneficial to him; and the minor subjects connected with this important science.

The culture of the earth is coeval with man; his beneficent Creator placed him in a well-stored garden, enjoining him "to dress and to keep it;" and after a fatal lapse of obedience, he was driven from his paradisical situation, a new injunction was laid on him, "to till" the ground, "that thorns and thistles" may not choak the better production of it. Adam, "by the sweat of his brow," so cultivated the soil, that it produced a sufficiency for himself and family: his sons he instructed in the art, and they communicated the same to their descendants: and thus the knowledge and practice of agriculture were promulgated through the early ages of mankind.

When the deluge had swept away from the face of the earth every vestige of human art, the ark excepted, Noah and his descendants found themselves under the necessity of reviving the practice of husbandry, as one of the surest means of procuring the necessaries and comforts of life. The methods pursued by the early generations are unknown to us, as are most of the implements which they employed; perhaps the mattock and coulter were their principal tools.

It seems probable that the inhabitants of the ages which immediately succeeded the flood, knew not the proper methods of restoring fertility to an exhausted soil; for we find them frequently changing their place of residence, as their flocks and herds required fresh pasturage, or their tillage land became unproductive. When the descendants of Abraham settled themselves in Palestine, agriculture began to raise itself into importance, and was considered not only as an useful but honourable employment. The Chaldeans, who inhabited the country where agriculture had its birth, cultivated the land with great assiduity, and seemed to have found out the means of restoring fertility to an exhausted soil, having plentiful harvests in succession, so that they were not obliged, as their predecessors had been, to be frequently changing their situation, in order to obtain a sufficiency for themselves and their numerous flocks and herds. The Phœnicians were also remarkable for their skill in agriculture. The Athenians taught the rest of the Greeks the use of corn, and how to cultivate the land that it might produce so wholesome a food. As the arts of agriculture encreased, and the blessings they afforded became more generally known, these savage Greeks forsook their acorns, and the wild roots of the field, and applied themselves assiduously to the cultivation of the earth; their kings encouraging such laudable pursuit. The old Romans esteemed agriculture so honourable an employment, that one of the highest praises which could be given to a man, was that of saying he had well cultivated his spot of ground. The most illustrious senators, in the intervals of public concerns, applied themselves to this profession.

The art of husbandry was at a low ebb until the fourteenth century; at which time it began to be practised in the midland and south-western parts of England; yet it seems not to have been cultivated as a science, until the latter end of the sixteenth century; when Fitzherbert, a judge of the common pleas, studied the nature of soils and the laws of vegetation with philosophical attention; and in 1534 published his first work entitled, "The book of Husbandry." Beyond which, small advances only were made in the theory until the time of the commonwealth; when sir Hugh Platt, one of the completest husbandmen of the age, discovered and brought into use a multitude of manures, little thought of by others, for meliorating and fertilizing exhausted soils. At the time of the Restoration, agriculture appears to have suffered considerable neglect, until Evelyn and Tull, by their literary labours, mightily promoted the study. Since their days, many valuable improvements have been made in the practice, and many are the writers who have rendered essential services, by enlightening the minds of their countrymen, and exciting them to emulation. In our own days, with pleasure we behold many respectable agricultural societies established in different parts of the kingdom, greatly contributing to the advancement of the practice as well as theory of agriculture; among which we must particularly notice that of high national concernment, instituted a few years since, under the title of the "Board of Agriculture."

About the year 1790, sir John Sinclair, a gentleman of genuine patriotic philanthropy, conceived an idea that such a board, properly constituted, would be of vast importance to the agricultural interests of the kingdom. Having, with much attention to the subject, matured his plan, and communicated the same to some of his parliamentary friends, in May 1793, "An address from the honourable house of commons was presented to his majesty, entreating that his majesty would be graciously pleased to take into his royal consideration the advantages which might be derived by the public from the establishment of a board of agriculture and internal improvement."

After surmounting the difficulties naturally attending the formation of such an institution, the charter for the same was drawn up, and sanctioned by the authority of the great seal, in August of the same year, and the founder elected president. To this society we are indebted for 80 volumes of the most useful agricultural knowledge, which could be procured from literary men, resident in, or intimately acquainted with the respective counties, under the title of a "General View of the Agriculture thereof, with observations on the means of Internal Improvement." The grand outlines of the plan of these views are, the geographical state of each county, the state of property, farm buildings, mode of occupation, implements, fences, arable land, grass, orchards, plantations, draining and other improvements, live-stock, rural economy, means of improvement, &c.

A work comprising so many important objects in the science of agriculture, cannot fail of producing national benefits, greater perhaps than have been derived from any other political institution of modern times.

Besides the county reports of agricultural views, the board have published sundry volumes of communications on various topics of husbandry, which have been transmitted to them by writers fully conversant with the sub-

jects of their respective communications. By pursuing such plan for a few years, and publishing to the world such communications, under some systematic arrangement, we may expect that agriculture will become the best understood, and the most accessible of any art in the whole circle of human acquirement.

Soils. A land considered as the basis of vegetation is called soil. The particles of the various solid, as well as less compact bodies, that are met with in nature, and which have been rubbed down and reduced by the successive operations of the atmosphere, and the agency of other natural causes, being mixed and blended together in different ways and proportions, constitute the earthy compounds, which, from their being capable of absorbing, and in some measure retaining, moisture, as well as giving stability, afford the means of support to various products of the vegetable kind, and form the bases of soils in general; while the materials proceeding from the decomposition and decay of numerous organized animal and vegetable substances, uniting with such compounds, compose the superficial layers of rich mould, from which plants chiefly draw or derive their nourishment and support.

Soils being formed in this manner, it is evident they must vary much, both in the qualities and proportions of the ingredients of which they are composed. In one situation or district one sort of material is abundant, and consequently enters largely into the soil; in others it is deficient, while those of other kinds are plentiful, and constitute the principal parts of the soils where they are found. Some situations too abound much more with animal and vegetable matters than others, which produce great diversity in regard to the soils. The harder and more firm substances of nature, being, on account of their structure, reduced more slowly, and with greater difficulty, into the state of earth, generally enter in much smaller proportions into the composition of soils, than those which are of a soft and pliable disposition, and which approach nearer to the quality of earth. Thus argillaceous, loamy, and vegetable matters are found to predominate very much in soils in their primitive state, and, according to their particular qualities and proportions, to constitute very material differences in their properties. Calcareous and siliceous earthy matters are distributed over some districts in great abundance, while in others they enter into the composition of the soils in much smaller proportions, and thus contribute to vary their textures and qualities.

One of the means of deciding in respect to soils, which, in many cases, when properly limited and exercised, by a person of sound judgment and duly experienced, is certainly not a bad one, though in some respects also defective, is that of determining from the nature of the plants that are naturally produced, and the degrees of their growth and luxuriance. Thus, where plants that are only accustomed to grow in good or peculiar sorts of soil, are met with in their natural and flourishing states in other places, the soils may be concluded to be of this or that kind, according to the circumstances in which they are found. The growth of certain sorts of timber trees and hedges, may also in various instances serve to direct the judgment, and likewise the appearances or colours of the mould in particular instances; the smell and the touch will also help to inform us of the quality of a soil: the best emits a fresh pleasant scent, when fresh dug up; and if due proportions of clay and sand are intimately blended, it will not much stick to the fingers in handling. But, however, that our readers may be informed of some of the leading principles which chemistry employs, in analising soils, we give him the following, which may be depended on.

1. To ascertain the quantity of water in any soil, take a pound of the soil, spread it very thin before the fire, or in the sun-shine in a warm day, let it lie till it is thoroughly dry; the evaporation of the water will be known by the weight lost.

2. To know if there are any metallic or earthy salts, take a pound of soil, pour upon it a pound of boiling distilled water, stir them thoroughly together, and let them stand for ten minutes, filter off the water through filtering paper, pour into what comes through a solution of the fixt vegetable alkali; if there is any earthy or metallic salt, a precipitation will take place.

3. To know if the salt contained has calcareous earths for one of its elements, take the filtrated solution, pour into it half an ounce of caustic volatile alkali, or continue to drop in this alkali till no further precipitation takes place; afterwards filtrate it, and pour to what filtrates through a little solution of fixt vegetable alkali; if there is any further precipitation, it shows that there is an earthy salt consisting of calcareous earth for one of its elements; if a precipitation took place upon the application of the caustic volatile alkali, it shows that there certainly are earthy and metallic salts.

4. To know if the salt contained is metallic or aluminous, add to the filtrated solution an infusion of galls; if there is any metallic or aluminous salt, a precipitation will take place; if iron, a purplish black; if copper, or allum, a grey: copper may also be distinguished from iron by falling in a blue precipitate upon the application of an alkali, while iron forms a greenish, and allum a white one.

5. To know if magnesia is an element of the salts found, take the filtrated solution, apply to it a solution of galls; if no precipitation takes place, apply caustic volatile alkali, which will precipitate the magnesia if it is an element of the salt contained.

6. To know if a neutral salt is contained, evaporate the filtrated solution with a boiling heat, till the whole water is nearly gone off, and let it stand to cool: if there is any neutral salt, it will crystallize.

7. To know if there is any mucilage, and what quantity, take 30 or 40 lbs. of the soil, boil it in 10 gallons of water for an hour, let the earth subside, pour off the clean solution, afterwards add four or five gallons of water to the earth, stir them thoroughly, let them stand to subside, pour off the water clear, mix it with the former, and evaporate the whole to dryness, putting it into a water bath towards the end of the evaporation: what remains is the mucilage, making allowance for that part of the decoction which was not washed out from the earth, and deducting the saline substances, which will crystalize if there is a considerable quantity, but will be destroyed in the operation, if in small proportion, as they generally are.

8. To know if there is any calcareous earth in the soil,

and what quantity, take $2\frac{1}{4}$ oz. of the dry soil, apply to it $\frac{1}{2}$ oz. of muriatic acid, and 4 oz. of water in a glass vessel sufficiently large; let them stand together till no more effervescence takes place; and if it was very considerable, pour in $\frac{1}{2}$ oz. more of the acid, let this stand also till the effervescence ceases, if any arises upon pouring it in, continue to add more acid in the same manner, until what was poured in last produces little effervescence, which is often at the first, and generally at the second or third half ounce. After the effervescence has ceased, put the whole in a filter, let the solution filtrate through; pour half a pint of water upon what remains in the filter, let that filtrate also in the same vessel; add to the solution thus filtrated $1\frac{1}{2}$ oz. of caustic volatile alkali for every ounce of acid used; if any precipitation takes place there is magnesia, earth of allum, or the calx of a metal (generally iron or copper) contained in the soil; after adding the volatile alkali, the whole is to be thrown into a filter again; after the filtration has taken place, pour into the liquor a solution of mild fixt vegetable alkali in water; if there is any calcareous earth in the soil, a precipitation will take place; continue to add the solution of the alkali till no fresh precipitation ensues, throw the whole into a filter, let the liquor filtrate off, pour on by degrees a pint of water, let that filtrate off also, dry what remains in the filter, it is the calcareous earth.

9. To know the proportion of sand and clay, take what remains in the filter after the first solution in the foregoing operation, and by the elutriation separate the sand from the clay, dry and weigh them; if there is any pyrites it will appear in the sand.

In the above processes the principal things to be attended to are, whether there are any metallic or aluminous salts, as these are absolute poisons, and therefore are to be decomposed by quick lime; whether there is such a proportion of neutral or earthy as to be hurtful, in which case the solution in process 2. will taste salt, a soil containing them in so large a proportion will hardly ever admit of culture for grain: whether there is calcareous earth, and in what proportion, as that ascertains the propriety of applying any manure containing it, and the quantity of that manure: what the proportion of sand and clay is which ascertains the propriety of adding clay or sand: whether there are pyrites, as that shows why, and when a soil will be long in being brought into cultivation; pyrites are best destroyed by fallowing, and afterwards applying lime.

The soils of this country have been described under numerous heads, and distinguished by a variety of vague local terms. They seem, however, to be capable of being considered and characterised, as far at least as is necessary for practical purposes, under the distinctions of

Clayey,	Gravelly,
Loamy,	Peaty or Mossy, and
Calcareous,	Vegetable Earthy soils.
Sandy,	

Each of these divisions must of course comprehend several varieties, according to the nature and preponderancy of the different sorts of materials of which they are constituted or composed. By different combinations of these substances all the intermediate kinds of soils are formed; and upon a proper mixture of them, in certain proportions, depends the success of the farmer's industry. Sand, clay, and water, are the grand component parts, whatever colour or texture the soil may happen to have.

Clayey or argillaceous soils. Soils of this kind differ very materially, according to the nature and quantity of the clay that enters into their compositions, and the adulteration which has been produced in it by the intermixture of different earthy matters, as well as various mineral, vegetable, and animal substances. For clays are, in general, far from being pure in the states in which they are found in the earth. They are in many instances united with large proportions of siliceous or sandy matter. On these accounts it is that the clayey soils of some districts are so abundantly fruitful and productive, while those of others are insuperably sterile and refractory.

These facts not only show that there is a prodigious variety in respect to the qualities of these substances, but that they must afford equal variety to the soils into which they enter, and therefore require to be more closely examined, and more nicely ascertained than they appear yet to have been, before all the varieties of soil usually classed under the denomination of clayey can be well ascertained and understood.

But these substances do not differ only in their properties and qualities, but likewise in their colours, and the closeness with which their particles are united. They are found in their natural states of various colours, such as red, white, blue, and yellow, and of different degrees of density, so as, in some instances, readily to admit of being united with the different materials that are applied, in order to meliorate their conditions; in others they can scarcely be made to join with them by any means in the power of the agriculturalist. In soils of the first kind, the quantity of siliceous or sandy matter, in general, bears a much larger proportion to that of the argillaceous or clayey, than in those of the latter, and in many cases too the mixture of other substances is proportionally larger. The nature of the clayey stratum, in respect to its thickness or thinness, as well as its contiguity, or remoteness from springs of water underneath it, is too commonly overlooked in considering these sorts of soils; but all these circumstances demand particular attention, and ought to have considerable influence in directing the means of cultivating and improving clayey soils.

It is obvious, from what has been already advanced, that, notwithstanding the differences that take place from the accidental mixture of different materials, in different degrees and proportions, all the descriptions of this sort of soils must possess more or less of the heavy and adhesive stiff qualities; and that according as these are more or less predominant, due respect being at the same time had to the various other circumstances that have been stated, the business of cultivation and improvement must be varied and applied.

Loamy soils. Loam denotes any soil which is moderately cohesive, that is, less so than clay, and more so than loose chalk. Soils, therefore, of this description admit of considerable variety. The substances that are most commonly found to contribute to the formation of loamy soils, are clay, sand, gravel, and chalk: and as either ingredient predominates, so is the soil denominated, as clayey loam, sandy loam, &c. Clayey loam is moderately cohesive, in which the argillaceous ingredient predominates; so that its coherence is greater than that

of any other loam, but less than that of pure clay. Besides the argil silex enters largely into the composition. Sometimes an oxide or calx of iron in small proportion is found blended with the clay and sand. In proportion as the argillaceous or clayey principle diminishes, they recede from the nature of the clayey soils; consequently the nearer the quantity of that substance approaches to that of the others, the stronger and more heavy will the loamy soil be. The differences in the lightness and friability of the soils of this class, in a great measure, depend on the relative proportions of the other ingredients. Where the calcareous ingredient greatly exceeds those of the sandy or gravelly kinds, they are neither so light or so pulverizable as where they are nearly equal, or where the sandy or gravelly matters considerably predominate over it.

In situations where this sort of soil has been but little disturbed, and consequently little changed by the artificial additions of either animal or vegetable substances, and those which it naturally contained not having advanced to the stage of perfect solution and decay, it is generally found of a light brown or hazel colour; but where much culture has been employed for a length of time, and large applications of animal and vegetable matters frequently made, the natural and artificial materials of these kinds having proceeded more nearly to the state of perfect resolution and destruction, it has an appearance that approaches to black. From these various circumstances the properties of the soils are likewise considerably altered and affected, as well as their colours changed.

From the soils of the loamy class being more friable and brittle, as well as more dry, than most of the clayey ones, they are capable of being tilled with much greater ease and facility, as well as much less strength of team, and at almost every season of the year. And, on account of their property of receiving and transmitting moisture more freely, they are less apt to be indurated by too much dry, or chilled by too much wet weather. Besides, they are more influenced on exposure to the agency of the atmosphere and other external causes, and thereby more adapted for the promotion and support of vegetation. And as they are found in most cases to be less disposed to the production of weeds, particularly those of the more injurious kinds, they can of course be kept clean with less labour, and without the expensive system of management which is requisite on many other kinds of soil.

Chalky or calcareous soils. Soils of the calcareous kind, which are composed of clay, sand, and chalk, occupy very extensive tracts of land in different parts of the world, and are marked with considerable diversity, as proceeding from the nature, properties, and proportions of the calcareous matter as it exists in them; the substances that are mixed and combined with it; the depth and qualities of the earthy stratum which is placed upon it, and the disposition of the sub-soil or basis on wich this is formed and deposited.

Calcareous matter is contained in many different stony substances, besides that of chalk, as marble, lime-stone, coral, and shells of different kinds; and in states of union with other materials, such as sand, the different simple earthy bodies, in different proportions, and in some instances with iron and magnesia. Its capability or powers of imbibing and retaining moisture is considerable, though not so great as that of clay. It burns to lime by proper degrees of heat, and absorbs carbonic acid gas, or fixed air in different proportions from the atmosphere, and returns again to the state of chalk or mild calcareous matter. It is found of very different degrees of hardness and friability, as well as of different states of fineness or pulverization, in different soils of the class to which it belongs. It varies also greatly in its effects in respect to vegetation; from the different matters that may happen to be combined with it in its primitive or original state. It has long been known to the practical agriculturist, that some sorts of lime may be employed in large proportions, while others cannot be used, except in very small quantities, without doing very considerable injury to the soil with which they are incorporated.

Calcareous matter, whether it is in the state of carbonat, or in the more active one of causticity, as quicklime, seems ultimately to promote the resolution and destruction of vegetable and animal substances; in the latter state, however, it acts with much greater violence on these materials, destroying their organization, and dissipating their principles more quickly, as well as robbing them more completely of the carbonic acid gas, or fixed air, which is so essential, while in the former it operates with great mildness, and only aids the resolution of those substances by gently promoting the process of putrefaction.

The proportions of clayey, loamy, and gravelly ingredients, which are conjoined with the calcareous matters of these soils, are various in different districts; where the argillaceous and loamy materials are comparitively in large quantities, soils of the heavier chalky kinds are formed, and where the sandy or gravelly are predominant, we have the lighter ones. There are also material differences proceeding from the earthy matter with which the calcareous ingredient is mixed in the state of soil. Where the quantity of this is small, and not reduced into any very perfect state of mould, the soil, as it is evident, must be poor and thin; but where the depth of this superficial stratum is considerable, and the animal, vegetable, and other substances of which it is composed, is advanced to a more complete stage of decomposition and decay, the soils are more rich and heavy. Some variety is likewise caused by the state of the under-stratum or sub-soil. If it is compact, and much intermixed with silecious or flinty matter, or have a mortary hardness, it is less favourable than where it is of a more open, brittle, or powdery texture.

Whatever appearances of lightness there may be in chalky soils, they require considerable strength in the team, where the staple or earthy stratum of the lands will admit of their being wrought to a tolerable depth; but where there is a thinner surface of earthy materials, less force of draught will be requisite. In the latter cases, the soil is, however, far more precarious and uncertain, as well as much less productive in respect to the crops that are cultivated upon it, than in the former. As chalky soils are not so liable to be injured by water as others, the business of tillage is much less impeded from that cause; but a dry season sometimes renders them so hard as to be totally incapable of being broken up, until they

have been moistened by the falling of a considerable quantity of rain.

Sandy or siliceous soils. Sands seem to have been gradually formed by the attrition and rubbing down of the various solid substances that are found in nature, especially such as are of the siliceous, calcareous, and stony kinds, and are of different degrees of fineness as they approach the size of gravel. They are also met with of various colours and appearances in different regions or tracts of country, such as white, dusky brown, yellow, and red. These differences, as well as those which respect their weight, tenacity, and other properties, depend on the nature and proportions in which many other materials enter into combination with them.

Where the proportions of clayey, loamy, or other earthy substances with which they are mixed, approach nearly to that of the sand, the heavier sorts of sandy soils are formed; but where these enter only in very small quantities, we have the light sandy soils; and where they are hardly met with at all, the soil is a loose blowing sand, most commonly of a white or brownish appearance. The portions of vegetable matters that are intermixed with different soils of the sandy kind are not less various than those of the clayey and loamy, from which considerable differences of quality are produced. These differences in their textures and compositions also introduce others which respect their powers of admitting and retaining heat and moisture. The openness and want of adherence in such soils, while they allow of the admission of heat and water more readily, permit them to be carried off with greater ease and expedition, they are therefore less permanently benefitted by their influence than the closer and more adhesive soils.

The light, open, and porous texture of sandy soils renders them much more easily cultivated and kept in order than those of the strong and close kinds; consequently the farms where they prevail are generally large; and when properly prepared, they are better adapted for the growth of many sorts of crops, such as those of the bulbous and tap rooted sorts. They have also another advantage, which is that of pushing forward the crops with more expedition. Whatever inconveniences attend them are mostly such as proceed from the want of a sufficient degree of cohesion among their constituent particles and solidity of texture. On these accounts they often counteract the best and most judicious management. The roots of the crops are liable to become naked and exposed from storms and various other causes; and if grain, to fall down and be lodged so early in the season as to render them of little value.

Gravelly soils. In the state of gravels which contribute to the formation of this class of soils, there is a variation of size in the pieces or particles of which they are composed, from that of a very small pea to the largest cockle. Where they become of still larger dimensions they are termed stones or rocks, according as they are in small portions or large masses; and the soils are then said to be stony or rocky, as the circumstances of the different cases may happen to be.

The beds of gravel, whether they are of the larger or smaller kinds, are mostly either of the siliceous or flinty kind, or of the calcareous or chalky; but the stones and rocks are of very different kinds. With these dissimilar substances, some others in different states of reduction and pulverization are blended and united in various proportions, so as to constitute gravelly soils that differ considerably in their textures and other properties. The chief of these are loams, and the mould or earthy matter formed by the destruction and decay of numerous animal and vegetable substances.

The gravelly mixture is sometimes also found to approach nearly to the surface, while at others it recedes considerably from it. In some instances springs rise immediately underneath; in others they are at a great depth, The bottom, or sub-soil, is likewise various; in some cases it is stony and rocky, in others it is clayey, or a rocky gravel, and sometimes sand, &c.

The open porous nature of gravelly soils disposes them to admit moisture very readily, as well as to part with it with equal facility; from the latter of which circumstances they are subject to burn, as it is termed, in dry seasons, which is not the case in the heavier or more retentive sort of soils.

Gravelly soils, from the lightness of their texture, and their not affording great resistance, except where the stones are large, or there are rocks, are not expensive or difficult in the means of cultivation. All the necessary business of this sort is capable of being carried forward with much ease and expedition, and the lands are in general soon brought into the proper states for the reception of crops.

Peaty or mossy soils. These soils consist chiefly of the roots of decayed vegetables, mixed with earth, mostly argillaceous, and sand, and a coaly substance derived also from decayed vegetables. They differ, like all the other kinds of soils, according to the nature of the ingredients of which they are constituted or composed, and the proportions in which these are found to prevail in them. Where the vegetable or peaty material predominates but little over the other substances with which it is mixed and incorporated, the lighter sorts of peaty, moory, or heathy soils, are formed; but where the other matters bear only a slight proportion to it, the deep and heavy, peaty or mossy, soils present themselves. In different districts the peaty matter is found of different depths, and of various degrees of density or closeness of texture, probably proceeding from some original differences in the vegetable substances from which it was formed, or the greater advances which it has made to the state of perfect decomposition or decay. The sub-soil in most of the deep mossy districts is of the clayey kind, more or less stiff and heavy, over which the peaty or mossy material is deposited, generally in a sort of stratified order; the first layer of which being commonly not more than ten or twelve inches in thickness, exhibits the appearance of a rich brown earth, in all probability from the incorporation of the loamy or clayey matters, with the peat or vegetable earth, laying immediately upon them, and constituting originally, perhaps, the surface of the ground. The layer that succeeds to this is mostly of a dark colour, and considerable thickness, apparently formed of a great variety of vegetable materials in the more perfect stages of resolution and decay, united together by time and other circumstances with more or less compactness and solidity. The uppermost stratum, or that which is placed upon this dense, peaty matter, is,

in general, of very pale colour, and very light spongy texture, arising possibly from the grasses, leaves, and other vegetable substances, of which it is formed, not having attained that state of decay which constitutes the darker sorts of peaty earth.

But in the more superficial peaty soils, little or nothing of this stratified appearance is met with. A coat of peaty earth, differing greatly in thickness according to the peculiarity of the situations, and other circumstances, is formed by a great length of time from the destruction and decay of successive crops of grasses, leaves and substances of the heathy or other kinds, and deposited upon, and intermixed with, the various harder materials of the soils which happened to be underneath them. By these means much variety is produced in the soils. Where the under-strata of earthy matter are tolerably good, and the crops of vegetables large and luxuriant, the better sorts of light peaty soils seem to be predominant; but where the quality of the under strata are indifferent, and the vegetable products scanty, as well as feeble in their growth, and principally of the heathy tribe. the poor peaty and heathy, or moory soils, are met with.

All peaty soils seem to be thus gradually formed by the deposition of vegetable matter, supplied by the dissolution and decay of aquatic and other plants that grow in low moist situations, as well as substances of other kinds brought down by water, from the high grounds in their neighbourhood. in the states of solution and diffusion, and gradually deposited from it on its becoming in a state of stagnation, by means of obstruction and stoppages proceeding from different causes.

From the nature of the composition of these soils, it is obvious that they must be very retentive of water, especally where they are of any great depth. Hence they seldom or ever become free from the excessive quantities of moisture, with which they are loaded in the rainy seasons.

Vegetable earth or soil. This kind of earthy material constitutes the superficial bed or stratum, in which plants for the most part vegetate in every sort of soil, and differs very much in different places, from the variations that take place in its depth, and the greater or less progress that has been made in the several substances of which it is composed, to the stage of perfect decomposition or decay. Some variety may likewise be caused by its being more intimately or more loosely mixed and blended with the other bodies that are found in soils. It seems probable too, that the earthy matter which is formed from the destruction of some sorts of vegetable substances may be better suited for the purposes of vegetation than that which proceeds from others.

Vegetables. from their containing a considerable portion of mucilaginous matter in a state of mixture with their other substances, become, in some measure, capable of solution in water, though the external surfaces of living plants, on account of the resinous and animalized materials that enter into their composition, are protected from its operation. From the former circumstance, and that of earthy matters being contained in them, which had been taken up in the state of solution with their fresh juices while growing, it is evident that large quantities of vegetable mould must be continually formed and deposited on lands by the natural decay of such substances.

But the formation of vegetable mould or earth is farther effected by means of the putrefaction or dissolution of such vegetables as are cut down, or otherwise destroyed, on the surface of the ground, and the application of various kinds of dung and composts. Where there have been in great abundance for a long time, there is mostly a deep rich surface soil of this earth; but where few vegetable products, and those of the less luxuriant kind, have been left to undergo the above process, or little assistence given by means of manures, the crust of surface mould is generally thin and poor. The resolution of vegetable matters is greatly promoted by a proper degree of moisture and heat, as well as a suitable state of the air.

From the preceding account of soils, we may perceive that those are the best which contain the greatest store of those principles which constitute the pabula of vegetation. Such are calcareous soils, in which carbon must exist in large quantities, from the natural attraction of lime for carbon, and where there will be a constant supply by means of this attraction. Soils formed from the decomposition of animal and vegetable matters, are in their natures eminently favourable to vegetation; for they contain hydrogen and carbon combined, together with the remains of animals and vegetables, as yet only tending to decomposition, with various salts resulting from the decomposition of animal bodies, water, earth, and gaseous principles.

Improvement of soils. From various causes, we perceive that some sorts of soil are less adapted to a vigorous production of vegetables than others. To improve the less fertile is a main branch of husbandry. According to circumstances, various methods must be employed; such as commixing one kind with another; draining such as are too retentive of moisture; irrigating such as are by nature too dry; and refreshing those with manures whose fertility has been exhausted.

Of commixing various soils. Chemical analysis has shown that substances of the calcareous kinds are the most beneficial in bettering the condition of clayey soils. Where the deficiency is in the want of calcareous matter, lime-stone, gravel, and calcareous marls are the most proper. If, however, these substances cannot be conveniently procured, a mixture of the coarser sands with lime and dung may be employed; or even coal ashes, sea sand, or chalk in the state of coarse powder may be advantageously used.

Loamy soils stand not in need of so much commixture with other substances as clayey soils; the soil of ponds, ditches, or even a small proportion of clayey soil may however be applied to advantage, and especially dung.

Chalky or calcareous soils of the heavier sorts may be benefited by the application of sandy loams; the lighter sort. by clay. dung, and argillaceous marl.

Sandy soils may be improved by applying calcareous marl, argillaceous and loamy ingredients, and by the use of the fold.

Gravelly soils of the calcareous kind may be improved by clay, clayey loam. or chalk.

Peaty soils. after being properly drained of their superfluous moisture, may be improved by the application of gravel, common sand, coarse earth, chalk, calcareous marl, dung, or sea sand. See Draining.

Irrigation or watering land. The systematic manner of watering meadow land, as now practised, is of modern invention, but of material importance to that farmer who possesses land of proper quality, and commands a stream of water suitable to the purpose; as he will be enabled to procure an earlier and fuller crop of grass than he could by other means.

Water, independent of any substances it may hold in suspension, is of universal utility in vegetation; being composed of two chemical elements (hydrogen and oxygen) which are highly favourable to vegetation, and directly and powerfully nutritive to plants. It enters, even undecomposed, as an aliment into the organization of vegetables. It is the only vehicle by which nourishment can be conveyed from solid bodies to plants. And whatever gaseous food the roots of vegetables receive, it is presented to them by the intermediation of water. Although thus beneficial when administered in season and due proportion, yet an excessive affusion of water tends to the destruction of many of the better grasses, and to the nourishment of rushes, mosses, sedge, and other aquatic weeds. A gentle affusion of this fluid, dispersing itself in all directions, never stagnant, never running with great impetuosity of current, more copiously applied in the light and under the heat of the sun than in the dark, operates with the best efficacy, as a promoter of vegetation.

The idea of watering meadows, so far as it relates to bringing the water upon the land, was undoubtedly taken from nature. It must have been always observed that winter floods produced fertility, provided the water did not remain too long on the land. The idea of taking the water off the land at will, and bringing it on again at will, is the effect of art; and the knowledge of the proper seasons to do this, is the effect of observation.

Suitable soils for water meadows are such as are of a sandy or gravelly nature, especially in the nearest subsoil. A bed of flints, or loose gravel, is the most desirable. It is also observable, that whatever may be the most abundant grasses in a meadow before irrigation, those kinds will always predominate which best agree with the soil and the water, provided the supply of water is regular and constant every winter.

There are two distinct methods of watering land, according as a less or greater quantity of water can be commanded. If the water is taken from a streamlet, near to the spring head, and the quantity small, only a small portion of land can be irrigated at a time, the water carriages and floating sluices are laid out, and cut in a form which (provincially) is by some called catch-work, by others frame-work. But where a river or large stream can be commanded, the work assumes another appearance, and being of greater power than the foregoing, is called flowing-work.

It is necessary, before entering upon works of this kind, to consider whether the stream of water to be employed will admit of a temporary weir or dam to be made across it, so as to keep the water up to a proper level for covering the land, without flooding or injuring other adjoining grounds; or if the water is in its natural state sufficiently high without a weir or dam, or to be made so by taking it from the stream higher up more towards its source, and by the conductor keeping it up nearly to its level till it comes upon the meadow or other ground. Further, if the water can be drawn off the meadow or other ground as rapidly as it is brought on.

This is to be done by the use of a spirit level, beginning from the highest part of the land that the stream can be commanded from, where the grounds on the different sides are the property of the same person, and weirs, or other works, as has been just observed, can be carried across the streams for the purpose of forcing the water, either wholly or in a partial manner, into a different course. After it has been raised as high as possible in this way, the level is to be formed from the surface of the water, carrying it on what is termed the dead level, allowing some small degree of depression for the flow of the current.

After this has been done, the land on the different sides of the stream, below the lines set out by the level should be minutely examined and inspected, as the whole may be irrigated if the command of water is sufficient. The extent that can be properly performed must however depend much on the degree of fall or descent from the entrance of the water and its out-fall, as well as on the declination of the more elevated parts of the ground.

The next circumstance of importance is that of deciding where to commence the business. This must depend on various points, which can only be settled by the judgment of the operator. If there is a full supply of water, the whole should be covered; but in the contrary case, the expense of cutting the mains or carriers on such levels in a sufficient manner should be considered; and where one side of the stream is better adapted to the purpose than the other, that on such side should be the first executed. And if the land most adapted to the purpose of watering is at much distance from the place whence the water is first taken, and there is not a supply for the whole of the land below the line of level on one of the sides, the expense of forming the carrier should be put in comparison with the greater advantage of irrigating the most suitable grounds, in preference to others that are nearer, without possessing equal advantages. It mostly happens that the beneficial consequences of irrigating at command are such as to overbalance that of forming the mains or carriers. Besides, though the supply of water may be insufficient in such seasons as are very dry, as it may be abundant in the winter time, the simply covering the land at that period may be more than adequate to the expense of the business, which is a circumstance that may render it more beneficial to lengthen the carriers, than by having them shorter to be confined to the watering of such lands as are less proper for the purpose. It is probable also, that in particular cases the winter irrigation may extend through the whole of the level that has been set out.

Where it can be done, it is best to begin with such parts as are contiguous to, or approach the nearest the mains or carriers; and after having passed the water over them, to mark the lowest places, where it can be carried off to the best advantage; and from such parts it should then be seen to which other lands the water can be conducted with the greatest facility and benefit. Where the natural shelving of the ground is considerable, less care is necessary; but where this is not much, it may often be requisite to convey the water in a slanting direction for a

considerable way, before lands sufficiently low for being covered by it are met with; as in this sort of business it is invariably necessary, in order to prevent the waste of water, to proceed with that which is first made use of to its final outlet into the river before the works on other divisions are commenced.

When the piece of ground to be floated is so much upon the level that the descent cannot easily be determined by the eye, it will be necessary to take an accurate level, and compare the highest part with the stream intended to be used, by which the degree of fall from the surface of the water to the highest point of the land will be ascertained; and in order to convey the water to this point, should it be distant from the stream, the sides of the ditch or canal should be sufficiently raised for the purpose not to keep the water in a dead level, but with such degree of descent as the two points will admit of. In the operation of cutting this canal or main feeder, it will be easy to preserve the proper degree of fall, having previously ascertained the length, for instance, in cutting 50 yards with a fall of five inches, it will be obvious that in every ten yards a descent of one inch should take place, this is necessary to keep the water in a constant lively motion. In some cases it may be necessary to have two main feeders, in order to affect a more equal distribution of the water; the depth and width of which feeders must be regulated by the supply requisite for the smaller gutters. Near to the mouth of the canal or feeder it will be proper to have a flood-hatch or clow, by which the water may be admitted or excluded at pleasure.

In forming the floating gutters, it is perhaps the best method to cut them at right angles, or nearly so, to the feeders; however, where the surface is uneven, in order to preserve a regular descent, a different direction must be given to them, the distance from each other being about ten yards, and the gutters becoming, as has been observed, gradually narrower as they recede from the main canal or feeder. The object in view being to throw the water as evenly over the surface as possible, these gutters should be so constructed that the water which has been introduced may overflow their little banks rather than run rapidly along the bed. Obstructions may sometimes occur, such as low parts, or deep ditches, over which a pipe or spout may easily be made to continue the progress of the water; and such as proceed from ridges, roads, or small eminences, by trunks or other contrivances made to convey the water underneath them.

It has been observed, that there are two distinct methods of watering lands, catchwork and flowing. The methods of making such works may be thus described. From the spring at A, Plate LXIX. Husbandry, fig. 13, take the level towards C; to include as much of the meadow BCDE as possible. Cut the trench or main drain AC of a width and depth sufficient to take all the water issuing from the spring, and convey it to the proposed meadow. Cut also the carriage gutter of a sufficient depth to take off the waste water which may fall into it; and also float sluices, &c. laid out by a level, placing sods taken from the sluices on the lower side. Was the meadow small, of a smooth surface, and regular declivity, the water might be let out of the main drain at different places, and so water the whole at once; but as these favourable circumstances seldom occur, recourse must be had to the floating sluices above mentioned, which must be cut at proper distances, such as 10 or 12 yards, according to the declivity of the land; the catches or frames may be about 30 yards apart.

If the meadow is large, it must be divided into catches or frames, by several carriage gutters, as in fig. 14, and a frame or two watered at a time, according to the body of water which can be commanded; and when the water is withdrawn thence, it may be conveyed to other frames.

In meadows thus watered from springs or small streams, it is of material consequence that the works should be kept as dry as possible between the intervals of watering; and as such situations are not affected by floods, and generally have but little water, they must be rewatered the more frequently; and as the top works of each frame will be in the way of getting more of the water than those lower down, care must be taken to give the latter a longer time, so as to make them as equal as possible.

Flowing meadows described. The other kind of water meadows, viz. those usually called "flowing meadows," require much more labour, and system, in their formation than the foregoing. The land applicable to this purpose being frequently a flat morass, the first object to be considered is, how the water is to be got off when once brought on; and in such situations this can seldom be done without throwing up the land in high ridges, with deep drains between them, as *a*, *b*, *c*, *d*, fig. 15, plate LXIX. A main carriage AB being then taken out of the river at a higher level, so as to command the tops of these ridges, the water is carried by small trenches or carriages along the top of each ridge, and by means of moveable stops of earth is thrown over on each side, and received in the drains below, from whence it is collected into a main drain CD, and carried on to water other meadows, or other parts of the same meadow below. One tier of these ridges being usually watered at once, is generally called "a pitch of work," and it is usual to make the ridges 30 or 40 feet wide; or, if water is abundant, perhaps 60 feet, and 9 or 10 poles in length, or longer, according to the strength and plenty of the water.

It is obvious, from this description, that as the water in this kind of meadow is not used again and again, in one pitch, as in the catch meadows, that this method is only applicable to large streams or to vallies subject to flood; and as these ridges must be formed by manual labour, the expense of this kind of meadow must necessarily exceed the more simple method first described; and the hatches that are necessary to manage and temper the water or rivers, must be much more expensive than those in small brooks.

Management of water meadows. As soon as the aftergrass is eaten off as bare as can be, the manager of the mead, (provincially "the drowner") begins cleaning out the main drain, then the main carriage, and then proceeds to "right up the works," that is, to make good all the water carriages that the cattle have trodden down, and open all the drains they may have trodden in, so as to have one tier or pitch of work ready for "drowning,"

and which is then put under water (if water be plenty enough) during the time the drowner is righting up the next pitch. In the flowing meadows this work is, or ought to be, done early enough in the autumn, to have the whole mead ready to catch, if possible, "the first floods after Michaelmas," the water being then "thick and good," being the first washing of the arable land on the sides of the chalk hills, as well as dirt from the roads, &c.

The length of this autumn watering cannot always be determined, as it depends on situations and circumstances; but if water can be commanded in plenty, the rule is to give it a good soaking at first; perhaps a fortnight or more, with a dry interval of a day or two, always taking the water off at the first appearance of white scum; after which, the works are made as dry as possible, to encourage the growth of grass, and to allow the land to pitch or sink close together.

Whilst the grass grows freely, a fresh watering is not wanted, but as soon as it flags, watering for a few days is necessary. In the months of October, November, or December, some meadows will bear the water for three weeks, which in February or March will not bear it one week, and in April or May not three days.

In all cases where the watering system is undertaken, except in the time of floods, it may be highly useful to disturb the mud and dirt in the bottom of the main carriers, or drains, before watering; a practice frequently adopted on the continent. Lime has also been thrown into these cuts by some irrigating farmers, and raked with a heavy harrow, or other implement at the bottom, which is a process that will be found to add considerably to the manuring quality of the water. It is probable that many other substances might be employed in the same way, and be thus spread over the surface of grass lands in a minute state of division, with vast advantage in promoting vegetation.

The great degree of verdure and luxuriance which almost immediately succeeds the occasional covering of grass lands with water, sufficiently demonstrate the power which it possesses in promoting vegetation. It is a means of fertility that has been employed for ages in more warm climates, with the most beneficial consequences in increasing the quantity of vegetable produce. But though it has been long in use in other countries, and of late more particularly attended to in this, the principle on which it produces its effects does not seem to be fully understood. In speaking of manure as the food of plants, we have already noticed some of the properties of this fluid that may be useful in the vegetable economy when taken up by the fibrous roots of plants; and there are still other ways in which it would seem to be advantageous in forwarding the growth of grass crops.

Winter and spring are the two seasons when meadows are usually watered, as from the month of November till the beginning of March; the experience of the operator can alone regulate this proceeding as to the length of time they should remain under water. In some districts the water is allowed to flow over the fields for several weeks together, with only the interval of a day or two occasionally; in others, the practice is to flood them the alternate weeks. When frosts set in, floating is usually suspended; but it has been remarked, that in such cases the succeeding crop of grass has been abundant. As the spring advances, much less floating is found to be necessary. However, in all cases, when floating is performed to advantage, the meadows should be laid dry between every watering.

Manures. An encreased population requires more abundant stores of food for man, and the beasts immediately under his command, than were before necessary: to this end, where the extension of land cannot be obtained, recourse must be had to the enriching of that which is already in possession, whenever it becomes deteriorated by constant and heavy cropping, with such plants as exhaust the pabulum of vegetables; and also to improve such soils as are by nature less adapted than others to the production of advantageous crops.

Besides the methods we have already spoken of for the improving of lands, mankind have discovered various substances, which, when judiciously applied, possess the power of encreasing the fertility of soil in a wonderful degree. These substances are numerous, and always near at hand. They arise from the decomposition of animal and vegetable matter, and from the agency of fossil and saline substances.

From the changes that are constantly taking place among bodies in nature, and the new combinations which are formed in consequence of those changes, a great variety of matters are unfolded, elaborated, and prepared for the nourishment and support of vegetable life.

Some of the substances which contribute in this way possess considerable fludity and volatility, such as water, and various gaseous materials, as oxygen, hydrogen, azote, and carbonic acid, in different states of combination. While others are more gross and heavy, and require to be applied and incorporated with soils, or spread out upon their surface, in order that they may produce their effects in promoting vegetation. It is principally to these, as being the means of sustaining different sorts of plants as crops, that the term manure has been given by practical writers on agriculture; though it is extremely obvious that they must undergo different changes, and be resolved into their more elementary principles, before they can be taken up, and contribute to the increase and support of vegetables. In the various materials which the art and industry of mankind have rendered capable of being beneficially employed in this manner, there is great diversity; some are found to yield the matters which are necessary for the support of plants much more readily and more abundantly than others, as animal, vegetable, and all such substances as are rich in mucilage, saccharine matters, and calcareous earth, and readily afford carbon, phosphorus, and some aerial fluids; while others that are greatly deficient in all or many of these principles, or do not readily part with them, are found to be of much less utility, when employed in the way of manures. This is probably a principal reason why some sorts of manures or substances, when put upon grounds, are so greatly superior to others, used at the same time, and in the same manner and proportion.

There are, however, many other ways in which substances, when applied to soils, may render them more fertile and productive, and contribute to the aid of vege-

tation. Some, besides furnishing such matters as are suitable for the purpose of promoting the growth of plants, are known to add considerably to the quantity of vegetable and other matters contained in the soils on which they are placed, and thereby provide a more suitable and convenient bed for the reception of the roots of plants; others contribute little in this way, but operate chiefly upon such materials as are contained in them, breaking down their organization or texture, and thus setting at liberty different volatile and other ingredients, by which new compounds are formed, and brought to such states as are the most adapted to the support of vegetable life; others again act principally by producing certain changes and alterations in the constitution or texture of soils, such as rendering them more open and porous, or more stiff and compact, and by such means bringing them into the most proper conditions for the bearing of different vegetable productions; and there are still others that contribute in all or several of these ways at the same time.

Substances of the animal kind, when reduced by the process of putrefaction, or other means, into a soft, pulpy, or mucilaginous state, are found by experience to afford those matters which are suited to the nutrition and support of plants with great readiness, and in more abundance, than most other bodies that can be employed. By chemical analysis it has been seen that the component materials of these substances, so far as agriculture is concerned, are principally water, jelly, or mucilage, and saccharine oleaginous matters, with small portions of saline and calcareous earthy substances. Hence animal matters, though they agree in some circumstances with vegetable productions, each having, in common water, saccharine, and calcareous matters, are far more compounded; and in animal substances, some of these materials are in large proportion, while in vegetables they only exist in a very small degree; and the jelly, which in some measure resembles the gum and mucilage of plants, differs likewise from them, in its having much less tendency to become dry, as well as in its property of attracting humidity from the atmosphere, and of running with great rapidity into a state of putrefaction and decay.

All these principles of animal substances are resolved by their ultimate decomposition into other matters, such as the different gaseous fluids that have been mentioned above, carbon, phosphorous, lime, &c.

Animal substances of every kind, on being deprived of their vital principle, have a quick tendency to take on or run into the state of putrefaction; a process which is considerably affected and influenced by the circumstances under which it is produced. But in the horny and more compact animal matters, this tendency to putrefaction and decomposition is, under similar circumstances, much less rapid than in such as are of a less firm and dense texture.

Hard animal substances. In the matters of this sort that are employed as manures, there is considerable differences in respect to their texture and firmness, some being quite firm and solid, such as bones, horns, hoofs, shavings of horn, and some other similar substances, while others are more soft and pliable. The bones of all animals are capable of affording much nutritious matter to plants, but those which are procured from cattle that have been killed when fat, are the best for the purposes of manure. Those which have been boiled are far inferior, in this view, to those which have not undergone that process, as by such means they are principally robbed of their oily and mucilaginous properties, and consequently must yield much less nourishment to the immediate crop, whether it be grain or grass. All these sorts of substances require to be ground down in mills constructed for the purpose, or otherwise reduced into small pieces, before they are laid on and mixed with the soil. They are excellent for potatoes.

These substances are constituted of a considerable proportion of mucilaginous or gelatinous matter, a slight portion of fat, and an earthy salt composed of the phosphoric acid and calcareous earth. If great heat be applied, they afford a large quantity of hydrogen gas, carbonic acid gas, and a volatile alkaline liquor. From the nature of these different principles, it is evident that some sorts of substances may be blended and united with the reduced particles of bony matters, so as to promote their effects, as manures, in a considerable degree, such as lime, chalk, peat, earth, and good vegetable mould, in suitable proportions, as by such means new combinations may be formed highly favourable to the process of vegetation.

Soft animal substances. There are various matters of this nature that may be of use for the purpose of improving land as manures, some of which have yet been but little attended to by the farmer. Of this sort are greaves, or the residuum which is left after the making of candles, and the scum which is collected in the boiling or refining of sugar.

Different trials with the former have fully convinced us that it is a substance that possesses great powers when employed as a manure. And although it is a substance which is generally procured at a high price, from its going a great way, and being a lasting manure, it may probably be more frequently had recourse to than has hitherto been the case. It is mostly procured in the state of hard compressed square cakes, though sometimes in a soft condition, without having undergone any pressure. When in the former state, the cakes must be broken down and reduced into as great a state of division as possible, which may be rather a troublesome and expensive process, except a mill, or some proper machine for the purpose, be employed. But when it has been even reduced to the finest state possible, it will still be improper for application as a manure, until it has been mixed and incorporated with a pretty large proportion of some rich earthy substance with which it may combine. Excellent for turnips.

A combination of lime and greaves, mixed with mould from the headlands, in the proportion of about 50 bushels of lime to a ton of greaves. This composition resembles sugar scum, which consists of lime and bullocks' blood.

Lime might thus be combined with bones or woollen rags, or with a compost of earth and night-soil; and would certainly greatly facilitate their conversion into manure, as well as render them more active in producing their effects in the support of vegetable crops. And by some of their properties being absorbed by the lime, during the time of their decomposition, and afterwards

parted with more slowly in the soil, they may also by such means be, probably, rendered more durable and lasting, as manures.

There are still more substances of the animal class, such as the blood, serum, wool, hair of animals, refuse of glue-makers, the cuttings of felt-mongers, the clippings of furriers, the scrapings of oiled-leather, and the chips or waste of shoe-makers, which may be made use of as manures, when they can be collected in sufficient quantities. These animal materials, from their abounding in mucilage and oil, their great attraction for moisture, and their being readily soluble in water, contribute quickly to the support of vegetation, but are not probably so durable in their effects upon land as many other substances. Hence they should only be made use of with a view to the immediate crop, which, we believe, is pretty much the case in those places where they can be obtained in such quantities as to be employed for the purposes of agriculture.

Various animal substances of the fish kind, as the blubber remaining after the preparation of oil from the whale, and other large fishes, and different sorts of small fish, both of the shell and other kinds, may be employed as manures; and also the offals of such animals, where they can be procured in a large quantity, as in large towns, sea districts, and where they are cured or prepared in great numbers for the market.

These substances may be readily reduced to that state which is proper for manure, by mixing with them a small portion of the carbonat of lime, and afterwards, according to circumstances, a quantity, two or three times more than the whole, of good vegetable mould.

The refuse of slaughter-houses and butchers' shops may likewise be prepared and made use of in a similar manner to that of fish. For as the manures that are formed from these animal materials are capable of affording much elastic volatile matters during their decomposition, they of course require to be well mixed and blended with such earthy substances as they can combine with, and render soluble, and in proportions suited to their powers, in order to produce the most beneficial effects on vegetation.

Animal dungs. The animalized substances that are, however, most generally made use of as manures, are the excrements of various kinds of animals, which are found in very different conditions, or states of preparation and richness, proceeding in some measure from the kind of food on which the animal has been fed, the matters with which they are incoporated, and the texture of the substances themselves.

The dung of fat animals is unquestionably more rich, and consequently possesses greater powers of fertilization than the dung of lean ones; and that the quality of the dung of every sort of animal will in a great measure be proportioned to the goodness or poverty of its food. Thus, when the animal is fed on oily seeds, such as lint, rape, and others of a similar nature, it will be the most rich; when kept on oil-cake, or those seeds which have been deprived of part of their oily matter, the next so; on turnips, carrots, and suchlike vegetable roots, the next; on the best hay, next; on ordinary hay, next; and on straw, perhaps, the poorest of all.

The urine of animals appears to be a more perfect extract from the animal system than the other; it is therefore surprising that this valuable substance is not more attended to by agricultors. Let it be mixed with the dunghill, or else carted to the field after it has passed through the putrefactive fermentation. Its effect on land is immediate.

Some manures of this kind, such as the soil of privies, is sometimes met with in a state fit to be applied to the ground, when not much mixed with fluid matters, such as urine. It most frequently happens, however, that it is in such a liquid state as to require other more solid substances to be blended with it, before it can be conveniently applied to the soil. In doing this, too little regard seems to have in common been paid to the choice of the most proper materials; but it is obvious, that such as can be most fully acted upon, and the most readily converted into the states suitable for affording the nutrition of vegetables, by the principles of matters thus employed as manures, must be the most adapted for the purpose, as well as the most beneficial. When, therefore, the manure made use of in this way is either wholly or principally constituted of such animalized matters, as from their fluidity are in an improper state or condition to be set on land without having other substances previously mixed with them, such peaty, boggy, or black vegetable earths should be chosen as contain large proportions of matter, which the ammonia or volatile alkali so abundantly provided by the decomposition of such substances may exert itself upon, and reduce into that state of solubility which is suitable for promoting the growth of plants.

The results of experiments attentively made in this way, indeed, clearly demonstrate that an inconceivable loss is incurred by the inconsiderate practice of exficcating human excrement, as well as the negligent custom of permitting the gaseous or liquid parts of dung heaps to evaporate or run away. The trials which we have been enabled to make also lead us to suspect that it is a much more wasteful practice to apply these liquors to ground in their combined state, than in conjunction with such earthy materials as have been mentioned above. Besides, much of them must be imperceptibly carried off by the process of evaporation, even when they are carried out in the most favourable seasons of the year; and they cannot in this way always be made use of on those soils that contain a sufficient quantity of those earthy materials or principles with which they can readily form combinations, and exert their most beneficial and fullest effects. It may be demonstrated, by experiment, that yard and stable dung should be applied to the land in its half decomposed state, and not be suffered to remain in heaps until the putrefactive fermentation has reduced it to over putridity.

We are decidedly of opinion, that the soil of privies is a manure of the most enriching kind, but that its effects are not so lasting as those of many other substances. In some trials which have been lately made with it, it has produced such astonishing fertility, as induces us to conclude that it exceeds all other sorts of manure that can be put in competition with it for the first year after its application. The second is of some service, but in the third its effects nearly, if not quite, disappear. The circumstances which render this sort of manure so imme-

diately active in promoting vegetation, and so quickly deprived of its beneficial influence, would seem to be from the great quantity of elastic principles which it contains in a loose state of combination, and the small quantity of earthy matter which it is capable of supplying to the soil, by the last stages of decomposition or decay.

This view of the nature of the manures afforded by different animals, should lead the practical agricultor to be more attentive to the subject, in order that he may render them more abundant, and be capable of employing them under the most favourable circumstances, which cannot be the case while they are, as at present, indiscriminately mixed and blended in the common dung-heap.

It is, however; from the larger animals that the farmer derives the principal part of the dung that is made use of as manure, in the cultivation and improvement of land. The dung of such horses as are highly fed being found, as has been already seen, to be much more valuable for the general purposes of agriculture, and some uses in horticulture, than that which is made by horses when fed with hay or grass only. Where the animals are kept in the latter way, it is probably not so good as that of well-fed cows and neat cattle in general, as in these it may, perhaps, become more animalized from the circumstance of their food being more intimately blended with the saliva, or other juices, during the ruminant state of feeding in such animals. The dung of horses is, however, in common much more disposed to the process of putrefaction, and cause more heat, than that of cows and other neat cattle; and indeed these are the chief distinguishing circumstances between them as manures. The dung of neat cattle may also, on account of its less disposition to run into the state of putrefaction, contribute more of the earthy material to the land on which it is applied. Hence, probably, its superior utility on the leaner and poorer or thinner sorts of soil. The dung and urine of animals when newly voided are not, except when the animals are morbid, in a putrescent condition, the length of time in which they remain in their bodies being too short for its fully taking place; but some degree of, or tendency to, putridity is constantly necessary to their discharge.

From the experiments that have been made with the dung of sheep, it is evident that it is equally valuable with that of many other animals that feed in the same way, but agriculturists have not yet turned their attention sufficiently to the means of collecting and preserving it, so that it may be used alone as a manure. The method by which it is at present applied to land is by folding the animals upon it, under which method of management, on many soils, a great part of the advantage must be derived from the operation or action of the ammonia of their urine upon the vegetable matters contained in them, as well as from the consolidation produced by their treading. It is well known that the urine and dung of sheep want no fermentation previous to its being applied to the land; the sooner therefore the seed is sown after folding, the greater is the effect.

Vegetable, as well as animal substances, when deprived of their vital principles or life, are soon rendered fit, by the separation, reduction, and ultimate decomposition, of their constituent principles, for the nourishment and support of new plants. This process is greatly promoted, in all kinds of substances, by the materials being exposed to the free influence or agency of atmospheric air, moisture, and a midling degree of heat; various matters are set at liberty, by which different new combinations take place, that are capable of promoting vegetation in different degrees, and upon which their utility as manures, perhaps, chiefly depends. The stages of this decomposition have generally been supposed regularly to succeed one another, from that which is productive of sweetness, through the vinous and acetous, to that which is the ultimate result of putrefaction. Different sorts and parts of organised matters, when dead, undergo many different sorts of chemical changes, which are different according to the degrees of heat, the quantity of water, and of air, to which they are exposed.

In the vinous fermentation or process which commences after the saccharine, carbon becomes united with pure air in a large proportion; and it is probable that, at the moment of their combination, while they are in the form of a liquid, and before they assume the gaseous state, they may be taken up by the roots of vegetables.

The substances of the vegetable kind that may be advantageously converted into manure are so extremely numerous, that it is impossible within our limits to describe them. All kinds of green vegetable productions may be employed in this way; such as the luxuriant weeds of rivers, lakes, ponds, and ditches; fern, and the refuse of different kinds of garden vegetables. Where green materials of this nature are made use of, they should always be cut down while in their juicy state, just before their flowers begin to appear, in order that they may be in the most suitable condition for becoming quickly putrid, and to prevent the injury that might otherwise be sustained from the vegetation of their seeds. They are afterwards to be collected into heaps of a moderate size, and their putrefaction promoted by their being thrown together as lightly as possible, and the occasional sprinkling of them with water, if the season be hot and dry; and as lime is found, when applied to vegetables in their green moist state, to disengage from them both hydrogen and azote, by the combination of which volatile alkali is produced, it may be advantageous to blend a portion of lime at first with the heaps, and afterwards add a suitable quantity of peat earth, or good vegetable mould, for the alkali thus formed to act upon. By this method, the quantity of manure from such substances may be greatly augmented, and rendered more valuable. But when dry materials, such as hay, straw of different kinds, fern, and rushes, such additions cannot be had recourse to with equal success, unless where much of the dung and urine of animals have been incorporated with them; but their resolution and decay may be greatly promoted by their being kept in a state of moisture, without the water being suffered to stagnate upon them, and by their not being permitted to be trodden down too much by cattle, or other means, in the farm yards.

Another beneficial means of vegetable manure, which is yet far from being sufficiently practised, is that of providing full crops of succulent green vegetables, such as clover, buck-wheat, tares, vetches, spurry, pease, beans, turnips, and many other similar plants, to be turned

down by the plough, in order that they may undergo the putrefactive process under the ground, and by that means be converted into manure, and supply the nutrition of plants.

Sea-weed is another vegetable production which is capable of being employed as a manure with great advantage, and should never be neglected where it is within the reach of the farmer. In some places it is the practice to spread it upon the lands as soon as possible after being cut from the verges of the rocks on the different sea coasts, or collected after being left by the tides, and to plough it in where this method is adopted, as little time as possible should be suffered to elapse after the cutting or collecting of the weed, before it is ploughed down; for as the plant in its green or succulent state readily decays and becomes putrid, if there be any considerable delay in the performance of the business, especially when the weather is hot, much of its valuable properties as a manure is dissipated, and carried away by means of evaporation.

Bark, which has been made use of for the purpose of tanning leather, may likewise be employed as a manure: when used in this way it should be collected into moderate sized heaps, before it has become dry by too much exposure to the heat of the sun and wind; and then by having a quantity of lime mingled with it, and being kept slightly moistened with water, its putrefaction and decay may be greatly promoted.

The mud taken from the bottom of rivers, ponds and other places where water has stagnated for some length of time, fresh or maiden earth, and the scourings of old ditches, are substances that may frequently be employed with advantage as manures, being principally composed of the recrements of decayed vegetable matters. They should not, however, be put upon grounds, especially those under grass, until they have been reduced into a considerable degree of fineness, by means of frequent turning over, and the mixing of a portion of lime, rotten dung, or other materials of the same kind, with them, in order to promote and render the decay of the more solid parts more full and complete.

Substances of the calcareous kind, which are to be considered under this head, produce effects more or less powerful in promoting the growth of vegetable crops, in some measure, according to the state and quantity in which they are applied, the nature of the soils on which they are employed, and the properties of the matters with which they are combined.

Substances that contain much saline matter in combination with their earthy and other ingredients, are found, in many instances, when properly employed as manures, to contribute greatly to the support of vegetation. The materials principally made use of in this way are the refuse of different manufactures, such as bleaching and soap-boiling, where they can be procured in sufficient quantities, as in the vicinity of large towns, and where such manufactures are carried on in an extensive manner; the ashes remaining after the combustion or burning of various green vegetable matters, wood, pit-coal, peat, &c. and some other substances, such as soot and sea-salt.

It is most probably to the different alkaline principles contained in these substances, from the great facility and power which they possess of acting upon and dissolving the parts of animal and vegetable matters, especially such of the latter kind as have been rendered insoluble by the absorption of the oxygen, or pure air of the atmosphere, from long or frequent exposure to it, that their beneficial effects as manures are chiefly to be ascribed.

But these substances, besides their forming in the soils, or the earthy materials with which they are mixed, such compounds as are beneficial in promoting the growth of vegetables may be useful in many cases when properly applied, and used in sufficient quantity, in correcting acidity, in altering the state or condition of the lands, as by the taking away of moisture from the surface where it prevails in an over-proportion in meadows and pastures, and thereby supports crops of coarse vegetables, and by rendering the texture of such grounds as are under the plough more open and friable, consequently more suitable for the reception of the roots of corn crops.

It is evident, from what has been already observed on the nature of the different substances that are capable of being made use of as manures, that they may frequently be mixed and blended with each other, or with substances of other kinds, and by such means be not only considerably increased in quantity, but in many cases rendered more effectual and more suitable for application than in their simple states; but at the same time, that some of them may be mixed and incorporated in this way with much more advantage than others; for though the general experience of farmers has fully shown the great importance and utility of employing compound manures, or composts, little attention has till lately been paid to the compounding or mixing together of such substances as are, from the principles which they originally contain, or which are formed from them in the changes which they undergo in the different stages of their decomposition, adapted to act in the most suitable manner for producing such combinations or alterations in the materials as are capable of being beneficial in the promotion of vegetation when they are employed as manures.

Farm-yard manure, which is the most general application of any, from its being formed by the decay of various kinds of vegetable matters, such as hay, straw, fern, and many other materials of a similar nature, with which the dung and urine of animals is incorporated and combined, must be considered as a compound substance. And from the large proportion in which such vegetable productions enter into its composition, and the quantity of earthy materials that is in most cases, especially where the management is upon a judicious plan, added by the laying of suitable bottoms, it is not so frequently necessary to be blended with other substances that are usually employed in forming composts. But from most of the vegetable materials that constitute the chief part of this sort of manure, being made use of in a dry and hard state, they do not so quickly ferment or run into the state of decay, notwithstanding the proportion of animalized matters that may be mixed with them; it therefore becomes an useful practice to turn them over, by which their complete putrefaction may not only be promoted, but the different materials be more minutely blended together, on both which accounts they may become more useful when applied as manure upon land. In the forming of this manure, care should also constantly be taken that the heaps be so situated as that they may not become too dry, or too

much soaked in water, as in either case they must be greatly injured. Whenever it may be requisite to incorporate any earthy material with this sort of manure, the agricultor should always carefully attend to the state or richness in which it may exist in the yard, and proportion such additions accordingly. It will, however, never demand nearly so large a proportion, as such manures as consist almost wholly of animal matters.

Where animal matters are collected and thrown together in any quantity, there can be little doubt but that a great increase of good manure may be provided by mixing with them, as has been already observed, rich surface-mould, peat-earth, or the scrapings of old ditches and roads; as by such a practice the ammonia formed during the decomposition of the animal substances is prevented from escaping, as would otherwise be the case, which, by combining with and acting upon the earthy materials, quickly renders them proper for the purposes of manure. As substances of the animal kind have been shown to run very rapidly into the state of putrefaction, they may frequently be incorporated with such vegetable materials as are little disposed, or with difficulty made, to rot or become putrid, and by such means useful composts be more expeditiously formed. In making use of such earthy substances as have been mentioned, it may be of much advantage to have them exposed to the influence of the atmosphere for a considerable length of time, frequently turning them over, before they are mixed with the manures, as by such means they become in a more pulverized state, and are capable of being more intimately blended with such materials, and afterwards spread over the land with much greater equality, a circumstance upon which their effects very much depend. If, in performing this business, the earthy substances be formed into a sort of ridge, about five or six feet in height, and nearly the same breadth in the bottom, they will be in the most proper situation for being united with dung, or other matters that may be employed.

In the application of manure to land, several circumstances are necessary to be considered, such as the state or condition of the substances which are to be made use of, the nature of the soils on which they are to be laid, the kind of crop that is to be promoted by them, and the season in which they are put into or upon the ground.

As we have already seen that changes are continually taking place from the moment the materials of the dung-heap are thrown together, to the period in which they are reduced into a black carbonic earthy matter; and that in most of the different stages through which they pass in this process of decomposition, such substances are formed as are capable of contributing to the nutrition and support of vegetable crops; it seems probable, that in cases where manures are to be turned into the ground, and such crops cultivated as require a supply of nourishment for a considerable length of time, they should be employed in their long or more imperfectly reduced states, as by the heat which is evolved in the commencement of their dissolution, the process of early vegetation may be greatly promoted, and their gradual decomposition and decay afterwards, under the ground, afford a more durable and regular supply of nutrient materials, and thereby contribute more effectually to the growth of the crops; but that where they are to be buried in, or applied to, the surface of the soil, and intended merely for the benefit and support of such crops as are of short duration, or quickly arrive at their full growth, they may be more advantageously made use of after they have been more fully and completely reduced, as in this state the manure is, in the case of grass lands, not only capable of being spread out in a more regular and uniform manner, by which it becomes more evenly as well as more generally carried down to the roots of the plants by rains, but it is in the most suitable condition for allowing the young plants the means of springing up with facility, and at the same time, whether used under or upon the soil, of affording the crops that abundant supply of nourishment which is necessary to their speedy growth and luxuriance, and by these means to contribute the most perfectly to the promotion of their increase.

And as in the slow and gradual decomposition of the materials which are made use of for manures, when slightly deposited beneath the soil, there is much less waste of heat and those elastic matters which contribute so greatly to the support of vegetation, than where they are made to undergo the various processes of dissolution in large masses, as in dung heaps, they may probably sometimes on that account be most advantageously employed in this state.

On this principle too the ploughing down of fresh vegetable crops, in many cases, in their most succulent states, may be a more economical as well as more beneficial practice; especially in such light and dry kinds of soil as will more readily admit of their gradual putrefaction and decay, than to cut and take them off for the purpose of being by other means converted into manure. It seems likewise probable, on the same grounds, that for the production of crops of bulbous-rooted vegetables on the more stiff and tenacious soils, the matters made use of as manures may be employed with the greatest advantage, when put into the earth before they have undergone any great degree of decay by means of putrefaction, as in this way there is no waste, the whole being ultimately converted and applied, though more slowly, to the support of the crops.

As to the season in which manures may be put into the soil, or spread out upon its surface, with the greatest benefit and advantage, though in practice it must, in some measure, depend on the state of the land and the convenience of the farmer, it should, in cases where they are buried in the ground, be as nearly as possible to the periods in which the seeds or roots which they are designed to support, are sown or placed in the earth; and in the latter case, or where they are to be laid upon the surface of the land, it ought to be just before the crops of grass, or other vegetables, begin naturally to spring or shoot forth.

And by the application of such manures as are employed in the way of top-dressings in the beginning of spring, they are laid on in the most favourable period for affording their nutritious principles, and for their being drank up by the roots of plants, consequently become useful at the time they are most wanted for the promotion of the crops, and the great waste which must otherwise be caused, either by the excessive falls of rains and floods in the winter season, washing down much of the valuable properties into the adjoining rivers and ditches, or the eva-

poration of their more volatile or elastic matters by means of the summer heats, is most effectually guarded against and prevented.

On all these accounts, therefore, farmers should contrive as much as possible to apply the manures, intended as top-dressings to grass lands, as early in the spring as it can be conveniently done. which may be easily managed on those that are dry, and on such as are inclined to be wet and poachy, it may probably be greatly facilitated by having small light carts constructed for the purpose, and placed on broad cylinders as wheels.

In the application of manures to lands under tillage, as well as those in the state of grass, there are a few other circumstances that require the attention of cultivators; such as the depth they may be deposited in the soil, the modes of putting them upon the ground, and the most economical methods of employing them.

In respect to the advantage of using one sort of manure in preference to another, it may be observed, that as animal matters are found in general to undergo more speedily the process of putrefaction or decomposition, than those of the vegetable kind, and as in most instances they afford those mucilaginous and elastic principles that contribute so largely to the support of vegetable life in greater proportions; such manures as are either wholly or in a great measure composed of them, must be the most beneficially employed, where quick and abundant supplies of nourishment are required, as in the growth of all the more gross and luxuriant crops, whether of grain, plants, or grasses; and that as those vegetable substances which contain saccharine, farinaceous, oily, saline, or mucilaginous principles in the largest quantities are ascertained from experience to proceed the most readily into the state of dissolution or decay, and consequently to afford more fully and more expeditiously the nutrient food of new plants, where manures are principally formed from them, they should be preferred to such as have been made from the harder and more ligneous vegetable substances, that contain such properties in scarcely any, or much smaller degrees, for all the purposes, of agriculture.

Of the natural spontaneous grasses. Having thus stated the nature and principles of the various soils which are met with on the surface of the earth, and shown the different modes of improving the same, it becomes us, in the next place, to speak of the best natural productions thereof, especially of the gramina kind; that from thence the agricultor may make his selection of such land as may be most profitable.

In our meadow and pasture lands we find a great variety of grasses, of which some are far more valuable than others; to know the good from those which are indifferent becomes the interest of the farmer; we therefore give him the charactes (accompanied with figures. See plates LXVIII and LXIX) of the most valuable, so classed in our catalogue as they stand in precedence of quality one to another.

1. Great smooth stalked meadow grass—Poa pratensis.
2. Hard fescue grass—Festuca duriuscula.
3. Meadow fescue grass—Festuca pratensis.
4. Ray grass—Lolium perenne.
5. Meadow fox-tail grass—Alopecurus pratensis.
6. Sheep's fescue grass—Festuca ovina.
7. Compressed meadow grass—Poa compressa. [Blue Glass.]
8. Rough stalked meadow grass—Poa trivialis.
9. Marsh meadow grass—Poa palustris.
10. Crested dog's tail grass—Cynosurus cristatus.
11. Knotty cat's tail grass—Phleum nodosum.
12. Sweet scented spring grass—Anthoxanthum odoratum.

Great or smooth-stalked meadow grass. This grass is considered as the best of all we have; it is early in its foliage, makes the best hay, affords the richest pasture, all sorts of cattle are fond of it, it is in all our meadows, and will continue in the same land much longer than any other grass.

Hard fescue. This is an early and productive grass, with fine foliage, which grows well on downs and rich meadows. It is well adapted for being combined with other grasses in forming sheep pastures, and stands high in esteem as a very good hay grass.

Meadow fescue grass. This is a grass that comes near in its appearance to ray grass, but to which it seems greatly superior, as being larger and more productive of foliage. It is strictly perennial and hardy, thriving well in moist soils, growing in all situations; and it abounds in the best meadows, in the best hay districts; is sweet, luxuriant, and quick of growth, affording rich pasture, and making good hay. In short, it seems well calculated to supply the deffects of ray grass. Besides, it has the quality of producing more seeds than most of the other sorts of grasses, which are easily gathered, and grow readily.

Ray or rye grass. This is a sort of grass that has been much in cultivation, but is deficient in some of the properties necessary for meadow or pasture lands. In rich moist meadows its foliage is abundant; and it seems probable that it is highly acceptable and nutritious in feeding cattle; its foliage is of rapid growth, and flowering stems continually shooting forth. It is best adapted to the loamy and sandy descriptions of soils; but it will succeed on any except stiff clay, and even on that it may be grown.

On converting ray grass into hay, it is necessary to cut it at a period previous to its being so ripe as to have perfected its seed, and changed to a yellow colour; for in this case a great part of the juices of the plant, which constitute a principal part of the nutriment it is to afford, will be converted into a species of straw, and its nutritive properties, be proportionably diminished.

Meadow fox-tail grass. It is in some measure distinguished by the largeness of its foliage, which is rather coarse, and by its producing a soft spike on a long stalk, early in May. If it be mown early, just as it comes into bloom, the hay will not be coarse. It shoots very rapidly after mowing, and produces a plentiful aftermath.

Sheep's fescue. This grass is praise-worthy both for the purposes of pasture and hay; sheep and other sorts of stock are fond of it, and are soon rendered fat in pastures where it prevails, giving to mutton a sweet delicious flavour.

Rough-stalked meadow grass. It delights in moisture, and situations that are sheltered; on which account, though there are few more productive, or better adapted for the purpose of hay or pasturage, it is tender, and liable to be injurd, by severe cold or drought; and in moist rich

ground it has been observed to grow tall, while in poor land it has been found equally diminutive. It is a grass well adapted to good, sound, moist loams. The produce is admirable for the feeding of all sorts of cattle.

Marsh meadow grass. This is a fine exuberant grass, and one of the best dairy grasses we have. It grows in all our rich marches, which are subject to be flooded in the winter; generally four feet high. Its panick, when full-blown, is wonderfully fine and flowing.

Compressed meadow grass. This is an excellent grass for parks and sheep walks, deer and sheep being fond of it; and as it is a dwarf grass, the blades seldom exceeding two inches, it makes a fine turf, and renders the flesh of the animals short, and sweet flavoured.

Crested dog's tail grass. This is a grass that is a favourite and wholesome food for sheep. It grows best in dry pastural lands, and will not thrive in meadows that are very moist. It abounds greatly in the best pastures, and is a blade grass that shoots up the first after the land has been mown; its thickest tufts afford much food for sheep in the time of snow and severe weather in the winter season. From the rapidity of its growth it may be apt to get coarse, if not cut down more quickly than is often the case.

Knotty cat's tail grass. It is a fine exuberant grass, very fit for dairy pasture and for cow-hay. It produces much rich milk, and kine are fond of it.

Sweet-scented vernal-grass. This is a sort of grass that comes early into blossom; and is also valuable for its readiness to grow in moist kinds of soil and situation, but in point of crop it is not so productive as some others; and it is well known to be the only grass of this climate which is odoriferous; the agreeable scent of new-made hay being produced almost entirely by it; and the green leaves, when bruised, readily impart this odour to the fingers, by which means the foliage may constantly be known.

Cultivation of grass lands. Lands in the state of grass must obviously be applied to different purposes, according to their nature, situation, and other circumstances. Those which are of the more moist kinds, whether from the nature of the soil or the peculiarity of situation, are for the most part kept under the scythe; while those of the contrary description, that are situated at a greater height, and of course, in most cases, possess a greater degree of firmness, are in general appropriated to the purpose of pasturage: though, in particular situations, where grass land is scarce, and consequently of great value, it is good management to convert them occasionally to the purpose of hay.

Meadow lands, from their being situated in the hollows and sloping sides of the valleys, where the staple and depth of soil of the lands have for a long time been continually increasing by the deposition of various sorts of vegetable and other matters brought down from the higher grounds, are, however, in general, in a considerably greater state of fertility, and evidently better fitted for the permanent production of grass than those from which they have derived their richness.

Management of meadow lands. From the greater retention of moisture in the vale land, in consequence of their situation, and the depth of vegetable matter, they are liable to throw up coarse herbage in many cases· more drainage, as well as other management, is necessary to bring them into the proper condition for the growth of good herbage, than is requisite in the hay grounds in the more elevated places. And by a more particular attention in these respects they would, in many instances, be rendered a vast deal more productive than they are at present, and at the same time afford a much better herbage. They would also admit stock upon them a much greater length of time, both in the autumn and spring seasons.

The most proper season for surface-draining grass lands is in the autumn, when they are somewhat firm and dry, as in the early spring months such lands are too full of moisture. The grips, or small open drains, should be cut obliquely, in the most suitable directions for conveying off the superficial stagnant water, the materials taken out being wholly removed. Much of this sort of draining may be performed at a small expense, and the beneficial effects be very considerable.

Meadow lands also demand much more attention in their management than those which are fed by cattle. In all cases stock should be turned upon the lands, and manures applied with much care, and only when the land is in such a state of dryness as not to be injured by the poaching in or breaking of the sward.

It must be evident, that the breaking of the surface, texture, or sward of grass lands must in all cases be prejudicial, not only by the destruction of plants, which is thereby immediately produced, but also by the retention and stagnation of water upon them in the holes and depressions from small portions of the turf being forced in.

The most proper periods of shutting up such grass lands as are designed for hay must, like those of eating them down in the autumn by stock, depend on various circumstances that can only suit the particular cases. In general, however, it is the best practice not to delay it too long. When the lands are not eaten at all in the spring by cattle, after the sheep have been removed about the middle of February, nothing further should be allowed to enter the meadows; by which means a quick vegetation is secured, as well as a more plentiful crop and a more early hay harvest. And in other cases, when eaten too late, there is not time for the grass to produce a full crop before the commencement of the hay season; of course the farmer sustains more loss than can be repaid by any advantage in the additional feeding he may obtain. This is therefore, the best practice where the view of the farmer is hay; and it should be particularly adopted and attended to in cow farms, where it is of much importance to cut early, to secure hay of a fine, grassy quality, for the purpose of producing large supplies of milk.

After the meadows or other grass lands have had the cattle and other sorts of live stock removed from them in the early spring months, and been shut up for hay, they should be prepared for the scythe, by having all sorts of obstructions picked up and removed. This work should always be executed as soon as possible, before the grass begins to spring up too much and conceal them, as it is difficult to perform the business effectually afterwards.

It is an excellent practice to have all sorts of coarse plants of the aquatic and other kinds, such as rushes, fern, docks, thistles, and various others, effectually drawn up and eradicated both from the hedge-rows and other parts of the fields, in order to prevent their running up to seed and disseminating themselves over the lands.

Mowing of hay lands. In the cutting of grass crops for the purpose of being converted into hay, it is necessary that they be in the most suitable states of growth and maturity for affording the best and most nutritious fodder. With this view, it would seem that they should neither be cut at too early a period, nor suffered to stand too long; as in the former case there will be considerable loss in the drying, from the produce being in so soft and green a condition, and in the latter from a large proportion of the nourishing properties being expended. It is probable, therefore, that grass, when mown before it becomes in full flower, while the rich saccharine juice is in part retained at the joints of the flower-stems, is in the most proper condition for being cut down, as at that period it must contain the largest proportion of nutritious material, but which then begins to be absorbed and taken up in proportion as the flowers expand and the seeds ripen.

But there are other circumstances besides those of ripeness to be attended to in determining the period of cutting crops of grass; as in some cases, where they are thick upon the ground, the bottom parts become of a yellow colour before the flowering fully takes place: under such circumstances, it will always be the most advisable practice to mow as soon as the weather will possibly admit; for if this is neglected there will be great danger of its rotting, or at any rate of its acquiring a disagreeable flavour, and of becoming of but little value. Where grass is very tall, as is often the case in moist meadows, it is liable to fall down and lodge, by which the same effects are produced. In this case also the mowing should be performed as soon as possible.

In the operation of mowing, the chief art consists in cutting the crop as close to the surface of the ground as possible, and perfectly level, pointing the swaths well out, so as to leave scarcely any ridges under them.

Hay-making. The great art in converting grass into hay consists in rendering it sufficiently dry to prevent its fermentation taking on too great a degree of heat in the stack or mow, and at the same time preserving a large proportion of the natural juice of the plants. Where this medium can be attained with the most exactness, the best and most nutritious hay will be produced.

In the making of hay, some attention should be paid to the quality of the soil and the kind of herbage growing upon it. The hard benty hay of a poor soil is in little or no danger of heating too much in the stack; it should, therefore, be put very early together, in order to promote a considerable sweating, as the only means of imparting a flavour to it, which will make it agreeable to horses and lean cattle, as it will be nearly unfit for every other sort of stock. It is the succulent herbage of rich land, or land highly manured, that is most likely to generate too great a degree of heat; of course grass from such land should have more time allowed in making it into hay. In moderately hot seasons the proper ground point of drying may be easily judged of; but when they are very hot and scorching it is easy to be mistaken; as in such weather the grass becomes crisp, rustles, and handles like hay, before the moisture or sap is sufficiently dissipated for it to be in a state fit to be laid up in large stocks. If that, however, be done when it is thus insufficiently made, it mostly heats too much, becoming mow-burnt in some cases.

The art of hay-making much depends in the due observance of the following rules, as nearly as circumstances will admit.

In the first day's process all the grass mown before nine o'clock in the morning must be tedded or spread out, great care being taken to shake it so as to leave it free from lumps, and to strew it evenly over the whole surface of the ground. It is soon afterwards turned, with an equal degree of care and attention; and if the number of hands be sufficient, they turn the whole again, or at least as much of it as they can before one o'clock. It is then raked into what are termed single windrows, or so as that each person may form a row at about three feet distance; and the last operation of the day is to put it up into grass cocks. The business of the succeeding day commences with the process of tedding all the grass that was mown the first day after nine o'clock, and all that was mown the second day before the same hour. The grass-cocks are then well shaken out into separate plats of five or six yards in breadth. The plats are next turned, and after that, the grass that was tedded in the first part of the morning once or twice, in the same manner as described in the first day. This business should all be performed before one o'clock, that the whole may lie to dry while the people are at dinner. After this the first thing is to rake the plats into double windrows, which is done by every two persons raking the hay in opposite directions or towards each other, forming a row between them of double the size of the single windrows, each being about six or eight feet distant from the other. They afterwards rake the grass tedded thus into single windrows; then put the double windrows into bastard cocks; and conclude by putting the single windrows into grass-cocks. The labour of the third day is begun by first tedding and spreading out the grass mown and not spread the preceding day, as well as that mown in the early part of the day, and then the grass-cocks are thrown out into plats as before, and the bastard cocks into plats of less extent. These narrow plats, though last spread out, are first turned, then those which were in grass-cocks; and lastly the grass is turned once or twice before one o'clock. When the weather has been sunny and fine, the hay which was last night in bastard cocks will this afternoon be in a proper state to be carried, as in fine seasons it may mostly be performed on the third day; but when the weather has been cool and cloudy, no part of it probably will be fit to carry. In that case, the first business after dinner is to rake that which was in grass-cocks last night into double windrows; then the grass which was this morning spread from the swaths into single windrows. After this the hay which was last night in bastard cocks is made up into full sized cocks, and care taken to rake the hay up clean, and also to put the rakings upon the top of each cock. And lastly, the double

windrows are put up into bastard cocks and the single ones into grass-cocks, as in the preceding days. On the fourth day the great cocks thus described are mostly carried before dinner. The other operations are similar to those of the former days, and proceed in the same order, continuing them daily until the whole is finished.

During the whole course of hay-making the grass should, as much as possible, be protected both in the day and night against rain and dew, by cocking.

The preserving hay of a proper green colour is a circumstance of some importance. In order to effect it, the bastard cocks, previous to their being carried, should be put up in the heat of the day, and remain in that condition till the following morning, when they must be turned and opened so as to dispel any damp that might induce it to heat in the stack, and in that way spoil the colour. The acquisition of a lightish brown colour in the stack is not found injurious to hay, but where it becomes of a dark brown from too much heat, it is said to weaken and relax horses that are fed upon it by its powerful diuretic quality. It is of course of inferior value for that purpose, but not the worse for fattening cattle with.

For the purpose of facilitating the business of getting the hay together in bad showery seasons, hay-sweeps have been constructed.

A contrivance of the first sort has been invented, and described in vol. xiv. of the Transactions of the Society for the Encouragement of Arts, Manufactures, &c. It is so constructed as to be drawn by four horses in pairs, but smaller ones might be made to be drawn by two, and is managed by two boys, one of whom drives each pair of horses, being mounted on one of them. Where the ground is level, little more will be necessary in order to assist the machine, than merely to break and turn up the rows of hay in different places. In catching or showery weather, such a machine may be particularly useful, in getting a field of hay, nearly dry, into large heaps in different parts of the field, whence it may be made into large cocks of half a ton or more each, with the utmost facility.

Stacking and thatching hay. The form of the hay stack is not a matter of much consequence, the long square, or oblong shapes are the most safe and convenient, especially when not too broad, as they admit the air the most fully. But the circular form for farm use, where straw is scarce, may be the most advantageous in the economy of straw in thatching.

The size of the staddle or stack bottom should be proportioned to the quantity of hay, but it is better not to have the stacks too large; 24 feet by 14 or 15 is for most occasions a good size.

The business of stacking hay is best performed, if possible, while there is a full sun, as by such means it is much improved. It is necessary to have a person that understands the art of setting up stacks, and a sufficient number of helpers to assist in spreading the hay and treading it well down. In building, the middle of the stack should always be well kept up, something higher than the sides. Where work of this sort is well executed, at leisure times, during the whole period the stack is building, the men are employed in pulling the sides and ends into proper form.

After the work of stacking has been completed, and the stack is pulled and topped up, it is left till it has sweated, and is perfectly settled, which is mostly the case in a week or ten days: the roof should then be well covered by a good coat of thatch. The roof should be dry when the thatch is put on, to prevent the hay from becoming mouldy. It is of great consequence that this sort of work be well performed.

It is a point not perfectly decided among agricultors, whether hay keeps better in stacks in the open air or in barns for the purpose. It is the opinion of most farmers that the first mode has the advantage in so far as respects the quality of the hay.

After-grass. Where after-grass is fed off by stock, there is much difference of opinion in regard to the most proper periods of turning in the animals. Some have contended that it is the best practice to let them into the field before the young grass has attained any very great head; while others maintain the opposite doctrine, and think it the best method to allow the grass to get up to a full bite before the stock is turned upon the land. Both endeavour to support their opinions by experience. But as they cannot be both of them true, it is probable that the extremes of each are to be avoided; and that, as in many other matters, the truth may lie in the middle. This is indeed equally supported by fact and the observation of the most intelligent managers; as when the cattle are turned in too early there is not a sufficient bite to keep up the condition of the animals; while in the contrary extreme, the stock so soon fill themselves, that much of it is trodden down and wasted afterwards in their roaming about the fields to pick the sweetest morsels.

Where much stock is turned upon after-grass in a full state of growth, there cannot be any doubt but that much loss must, as has been just observed, be sustained by the treading down and rendering the grass unfit for being eaten off. It is therefore perhaps only by beginning the pasturage of after-grass when in the middle state of growth that it can be consumed to the best advantage, and without loss in either of the ways that have been just noticed.

In the stocking of after-grass, some attention is necessary not to have too great a number of animals on a given proportion of land. One cow to the acre on well-grown after-grass is an ample stock. Good grass-land may, however, admit something more.

Management of pasture lands. Having explained the different methods of management that seem necessary to the cultivation of those sorts of grass lands that are chiefly applied to the purpose of producing hay, we shall now describe the modes of practice which appear requisite in such as are almost wholly appropriated to the support and fattening of live stock.

The grounds that are the most perfectly adapted to this use are, all those which have a considerable depth of good mould, and at the same time that they afford a good herbage, are so dry in their nature as to admit the animals to feed upon them at almost all seasons without injury by poaching. Coarse rushy lands may, however, in many cases be converted into good pastures, by proper attention in draining, and cutting over the rushes in the early part of the spring, and about Midsummer, as by these means the plants decay, the young shoots

being afterwards eaten by young stock, and the good grass plants allowed to flourish.

Pasture lands should likewise, as much as possible, possess properties in the nature of their grasses that are the most advantageous for the particular method of management under which they are to be conducted. In this view, some may be more adapted to the producing of milk or butter, others of cheese, and others again of feeding or fattening animals. It is in some measure on this account, as well as that of local convenience, that different modes of management are employed on grass lands.

The difference of situation in pasture lands has likewise much influence in directing the uses to which they may be applied with the greatest benefit. The higher or more elevated grounds being in general more proper for sheep, while those of the lower and more inclosed kinds are mostly better suited for the purpose of neat cattle or other animals under the fattening system.

Pastures, when not well attended to, are frequently prevented from being properly fed, by various kinds of low shrubby plants, such as those of the alder, brier, broom, furze, and other sorts that shoot out upon the surface; these which should always be extirpated as soon as the business can be conveniently done; as by their remaining upon and shading the ground they render the herbage sour, and improper for the food of cattle. This sort of work may be performed by cutting them closely down as they rise in the early spring months; but a better practice is to dig them completely out.

Where pastures are productive in grasses of the more sharp coarse bladed kinds which rise into tufts or tussocks, and which are known to agricultors under the titles of pink or carnation grasses, it is a certain indication that the soil is too retentive of moisture, and stands in need of draining.

The improvement of the fertility of pasture grounds may be effected in different ways, as either by the direct application of manure in its natural state, such as that of rotten dung, lime, marl, or in that of earthy compost, occasionally, over their surfaces in a thin even manner; or indirectly by the folding or confining of sheep upon the land during the time they consume other sorts of green food, such as turnips, &c. The latter mode is unquestionably the most advantageous and convenient, as it is in but very few situations that the former can be practised without robbing the arable or hay lands of their property.

In explaining the methods of management that are necessary in the cultivation of arable lands, in order to afford a suitable state of soil and nourishment for the growth of grain or other crops, it will be proper to consider them as relating to grounds that have not yet been brought under the plough, and such as have been already in the state of tillage.

Removing obstructions to tillage. In the first place, the removing of stones, the eradicating of wood, the destruction of different sorts of plants, and the removal of such degrees of wetness as may be injurious, before the business of ploughing or loosening the mould of the soil can be properly carried on. The stones that oppose obstruction, in this view, are principally either such as are met with in a loose state in the ground on its being ploughed, or such as are fixed in the soil, and incapable of being removed without much labour and difficulty. Some of these last are often of such a size as to present themselves upon the surface, and cause much land to be lost, by their not permitting the plough to come near them. Those which are concealed below the surface are, howhowever, the most detrimental, as the implements are frequently destroyed, and much inconvenience experienced from them, before they can be perceived by the ploughman, though he may be perfectly attentive to the circumstance.

In all cases, land should be as much as possible cleared from such stones as retard or prevent the operation of the plough before the business of tillage be undertaken; as without due attention in this respect considerable loss may be sustained by the breaking of implements, and the great delay that must take place in the work.

In the clearing of lands from wood, different methods must be pursued, according to the nature of the wood with which they are covered. Where there are large trees of the timber kind, they should be completely grubbed up at a proper season of the year, care being taken that the roots be as much as possible removed.

In cases where broom, furze, brambles, or thorn shrubs, have become of considerable size, the general method of proceeding is to cut them down as close as possible to the surface of the ground, and afterwards to dig round, and grub up the roots in the manner that the larger trees are cleared. With furze it is sometimes customary to set fire to them, in order to uncover their stems before any attempt is made to grub them up; but this is a practice that ought to be as much as possible avoided, from the danger that may attend it, and the loss of the furze, as well as a large portion of the valuable vegetable matter accumulated in many cases beneath them.

As it has been found from experience, that such lands as have been attempted to be cleared from brushy plants of this kind, especially those of broom and furze, are extremely liable, from the roots and seeds that may be left in the soil, to have them coming up again in great abundance after they have been laid down to grass; it should be a practice to keep lands that are much disposed to their production in the state of tillage for such a length of time as may be fully sufficient, by the various means of cultivation, and the application and blending of lime and other suitable manures with them, to have them as completely removed as possible; and that when they are restored to the state of grass, to have them pastured, as much as can be conveniently done, with sheep.

Heathy lands should be cut as close to the surface of the ground as it can be conveniently done; and lime, in its caustic state, should be applied in large proportions.

When this sort of ground has been broken down and pulverised as much as possible by the operations of ploughing and harrowing, it should always, where not too stiff, be sown with some sort of close, luxuriant, green crop, such as turnips, peas, and tares, that may be fed off by sheep; but where it has a sour quality, and is more stiff, clayey, and adhesive, those plants that strike more deeply into the soil, as beans, rye, and oats of the grey kind. In many cases too, rape, peas, clover, and vetches, will succeed in a very beneficial manner. But as the principal intention in most cases of breaking up

this sort of land, is that of bringing it in a cheap and expeditious manner to a suitable condition after a grain crop or two for growing grass, the green crops, of whatever description they may be, should be consumed by animals upon the ground.

And in whatever method such lands may be brought into the state of cultivation, the processes of tillage should not be carried further than the destruction of the heathy or other coarse plants, and the removal of the sour and unfriendly disposition of such soils for the growth of useful vegetable productions. They should be then restored as soon as possible to the state of grass or pasture.

There is another description of land that is frequently to be brought into the state of tillage; this is that of the boggy kind. In these the first thing, after having them well drained by the cutting of proper ditches, which, where they are large, may serve for their inclosure, and by giving the ridges a suitable form in order to aid this, is to pare off and level the surface by means of the spade or plough; such matters as are of little value being deposited in the hollows, while those that are of a good quality may be mixed into a compost with good dung, where it can be procured, or with lime; together with the spare earth taken from the ditches, which should be immediately spread equally over the land, and incorporated as much as possible with it, by ploughing it up with a very slight or ebb furrow, in order that the uniting materials may not sink too deep for affording due support to the crop, that it may be cultivated. Indeed, though deep ploughing may sometimes be of utility in first opening up these soft soils, it should never be had recourse to when the application of manure is to be made; and on this account also the ploughings after the taking of different green crops should only be slight. It is seldom proper to continue soils of this description for any great length of time in the state of tillage, as from their great moisture, on account of the general flatness of their situation, and their being liable from continued ploughing to become very loose and open, so as not to afford proper nourishment and stability to the roots of the crops, this sort of land will in general be the most advantageous in the state of grass.

The most beneficial sorts of crops for these soils will in general be turnips, rape, or potatoes. The light and drier parts will be the most adapted to potatoes, as their bulbous roots will be there the most able to spread and extend themselves, and consequently produce large crops. These crops will, in the stiffer sorts of these soils, leave the land in a suitable condition for wheat or oats, and in the lighter for barley or rye.

Moss lands, from their being much disposed to the throwing up of grass, are not so proper for the growing of grain crops, but a crop or two may frequently be taken after potatoes or turnips, especially where liming has been performed some length of time. Oats and barley are mostly good crops, but such land is often too light for wheat. Where barley is employed, grass seeds are frequently sown with it, but it is probably a better practice to put them in separately. On those soils, rye-grass, as well as white and yellow clover, have been found to thrive extremely well, especially where they were in a proper state of preparation for them, as by the growth of potatoe or turnip crops. And though red clover has not always succeeded, it is probable, that in such mosses as are not of the deep kind, it will be found an useful plant. In some districts it has been found that clover may be sown with great advantage immediately after the potatoe crop, when it has been taken off early.

It is evident, from what has been advanced, that as there is much variety in soils of this kind, they will of course require different modes of tillage. Where they are very thin, and deposited upon a loamy or clayey substratum, it may be a good practice to plough so as to bring up a portion of them, by which, and the use of lime, the land may be rendered highly productive.

Ploughing. This, or some other method of loosening and turning up the superior parts of soils, is constantly requisite in order to render them suitable for the reception of the seed or crop that is to be cultivated. It is by means of this kind that a convenient bed for the roots of the young plants, and a proper condition of the land for supplying them with due nourishment, is in a great measure provided, as well as a proper state of dryness in many cases afforded.

There are certain circumstances that constantly demand notice in the practice of ploughing land. In all the stiff, heavy, and more adhesive kinds of soils, that are much disposed to the retention of moisture, whether they be perfectly clayey, or have more of a loamy quality, it should be a common rule never to plough or turn them up when wet in any great degree, except where the nature of the crop requires it. And further, great injury is produced by the treading of the team, as well as a much greater power necessary in performing the operation. But at the same time they should not be permitted to become so dry and hard as to afford too great resistance in that way, before the operation is proceeded upon.

But in the dry, sandy, and probably in some of the more mellow and friable kinds of loamy soils, the business of ploughing, especially for the putting in of the seed, may be performed when they are in a state of considerable moisture, not only without their suffering any inconvenience, or the seed being injured, but often with advantage, as they are liable to part with the watery particles that they contain too readily. On this last account the very dry sorts of sandy land should, whenever the weather is hot and dry, merely be stirred in such way as may be necessary to prevent the growth of weeds, otherwise the great exhalation of moisture in such seaseasons may render them too dry for the healthy vegetation of the seeds or plants that may be sown or set upon them.

In regard to the depth and frequency of ploughing lands, they must constantly depend, in a great measure, upon the qualities and the sorts of crops that are to be grown. But in general the different preparatory ploughings should be deeper than those of the seed furrow, which ought mostly to be light, and the slice not too much laid over, that the seed, especially where the broadcast method of sowing is adopted, may be the more perfectly covered.

Upon all light soils it is necessary to preserve, at six or eight inches below the surface, what farmers call a pan; that is, the staple, at that depth, should be kept unbroken; by which means manure will be kept longer

on the top: and in dry seasons the less depth the pan has, the less liable the corn will be to burn, provided the pan consists of earth, and not of rock; because the roots of the corn will find more moisture by striking against a body of close earth than they will in a greater depth of hollow earth; as it is evident the former preserves more moisture in dry seasons.

In regard to the frequency of ploughing or turning over ground, in order to prepare and render it suitable for the production of good crops, it is obvious there must be much difference according to the nature and condition of the soil, as well as the kind of crop that is to be grown. The stiff, clayey, loamy, and even chalky soils will, in general, stand in need of more frequent stirring, either by means of the plough, drag, or harrow, in order to separate and break down their tenacious particles, than those of the sandy or gravelly, and more light kinds, in which there is much less adhesion. Besides, where lands have been in a course of tillage for some time, whether they are of a clayey, loamy, or even sandy quality, they may require less frequent stirring than where the contrary is the case. And where the method of putting the seed into the ground by means of drill machines is to be had recourse to, a fine state of tilth will, in general, be indispensably necessary.

The nature of the crop that is to be cultivated must, however, in most cases, direct the number of ploughings that may be necessary, as some demand a much finer state of tillage than others; though in most cases a well-reduced earth is favourable.

In the choice of implements for the performance of this business, the agricultor should be careful that they are well suited to the nature and quality of the land, as it is not possible that any particular sort of plough can be employed with equal facility and advantage on soils of every description. The more stiff and heavy kinds of land will require ploughs of more strength than those of the thin chalky, and a light, sandy, or gravelly nature. The former may mostly be managed in a proper manner by any of the well-constructed kinds of strong ploughs; as the Somerset single-wheel plough, the Hampshire two-wheel plough, and the latter by those of the light sort, as the Rotheram plough, the Norfolk light two-wheeled plough, or the double-furrowed plough. See Plate LXX. Ploughs, &c. But whatever description of plough may be had resourse to, it is a matter of the greatest consequence that it be properly formed and attached to the draught, as where these points are not minutely attended to, there must constantly be a considerable loss in the economy of labour and time, as well as in the completeness of the work.

HUSK, the same with what botanists call the calyx, or cup of a flower. See CALYX.

HYACINTH, in natural history, a genus of pellucid gems, whose colour is red with an admixture of yellow. See ZIRCON.

HYACINTHUS, a genus of the monogynia order, in the hexandria class of plants, and in the natural method ranking under the 10th order, coronariæ. The corolla is campanulated, and there are three melliterous pores at the top of the germen. There are 17 species, of which the most remarkable is the orientalis, or eastern hyacinth. Of this there are a great number of varieties, amounting to some hundreds, each of which differs from the rest in some respect or other.

These plants are cultivated with the greatest success in Holland, whence great numbers are annually imported into Britain. Each variety is by the florists distinguished either by the name of the place where first raised, or the person who raised them, or the names of illustrious personages, as of kings, generals, poets, and celebrated ancient historians, gods, goddesses, &c. They are sold by all the seed-dealers. The prices are from 3*d.* per root to 5*l.* or 10*l.* or more; and some varieties are in such high esteem among the florists, that 20*l.* or 30*l.* will be given for a single bulb. They are hardy, and will prosper any where, though the fine kinds require a little shelter during the winter. They may be propagated either by seeds or off-sets from the roots.

HYADES, in astronomy, seven stars in the bull's head, famous among the poets for the bringing of rain. The principal of them is in the left eye, called by the Arabs Aldebaran.

HYALITE, in mineralogy, a stone frequently found in trap rocks. It occurs in grains, filaments, and rhomboidal masses. Texture foliate. Fracture uneven, inclining to conchoidal; sometimes opaque; specific gravity 2.11; colour pure white. Infusible 150° Wedgewood, but it yields to soda. According to Mr. Link it is composed of

57 silica
18 alumina
15 lime
——
90 and a little iron.

HYDATIDES, in medicine, little transparent vesicles or bladders, full of water, sometimes found solitary, and sometimes in clusters, upon the liver, and various other parts, especially in hydropical constitutions. See MEDICINE.

HYDNUM, a genus of the natural order of fungi, in the cryptogamia class of plants. The fungus is echinated or prickly on the under side. There are six species. One of them, named the imbricatum, is a native of Britain, and is found in the woods. It has a convex hat, tiled, standing on a smooth pillar, of a pale flesh-colour, with white prickles. It is eaten in Italy, and is said to be of a very delicate taste.

HYDRA, in astronomy, a southern constellation imagined to represent a water-serpent. The number of stars in this constellation in Ptolemy's catalogue is 25, and in the Britannic catalogue 68.

HYDRA, a genus of vermes zoophyta. The generic character is, animal fixing itself by the base, linear, gelatinous, naked, contractile, and furnished with setaceous tentacula, inhabiting fresh waters, and producing its deciduous offspring, or eggs, from the sides. The hydra viridis inhabits the stagnant waters and slowly running streams of Europe, generally on the surface of plants, and appears like a little transparent green jelly, when contracted and transparent: when expanded it is a linear body, fixed at one end, and surrounded at the other by tentacula, or arms placed in a circle round the mouth, and gradually producing its young from the sides, which at first seem small papillæ, increasing in length, till they assume the form of the parent, and then drop-

ping off. Like all its tribe, it has the power of reproducing parts which have been destroyed, and if cut or divided in any direction, each separate part becomes a perfect polype. See Adams on the Microscope. There are five species.

HYDRACHNA, a genus of insects of the order aptera: the generic character is, head, thorax, and abdomen united or connate; feelers two, jointed; eyes two, four, or six; legs eight, formed for swimming. The genus hydrachna, allied in the closest manner to that of acarus, under which the only species known to Linnæus were arranged, was first instituted by the ingenious Muller, by whose industrious researches many new and curious kinds have been discovered.

Among the larger insects of this genus is the hydrachna flaccida, so called, in order the more clearly to distinguish it from one or two others with which it may sometimes be confounded. Its size is that of a small pea, and its colour a very bright red: its shape is nearly globular, but the skin is of such a nature as to yield to every inclination of the body, so that the whole, when taken out of the water, has an irregularly flaccid appearance. This is most remarkable in the full-grown animal, which is also of a much more torpid nature than the rest of the genus, which are animals of great celerity of motion; and indeed the young or unadvanced individuals of the present species are of a more compact appearance, and swim with a greater degree of swiftness than the larger ones. The hydrachna flaccida is not very uncommon in stagnant waters.

Of all the hydrachnæ yet discovered by far the most elegant is the hydrachna geographica, so named from the fancied map-like distribution of its variegations. It is one of the largest of the genus, equalling the size of the former: it is occasionally seen in clear ponds and other stagnant waters, but is one of the rarer kinds: its shape is globular, and its colour a polished black, decorated with carmine-coloured spots and patches, which, in a certain light, are accompanied by a kind of gilded lustre.

Hydrachna roeseliana is named after Roesel, by whom it is figured in his well-known work on insects. It is of equal, or even superior size to that immediately preceding, which in many points it seems greatly to resemble; the ground-colour however in this is red, with black variegations, disposed in a different manner from those of the former. It is found, though not very frequently, in stagnant waters.

Among the smaller, or middle-sized hydrachnæ, one of the most common is the hydrachna extendens, which if of the size of a very small hemp-seed, and of a bright red colour, without any variegations; it is extremely nimble in its motions, and always carries the hinder pair of legs, which exceed the rest in length, in an extended posture.

Hydrachna araneoides is a small species, of a brown colour, clouded with red, and marked on the back by a very large oval patch of the same colour. It is found, like the rest, in stagnant waters, and has the habits of a young spider.

Some of the genus are distinguished by a kind of cylindric process at the end of the abdomen; of this kind is the hydrachna buccinator. It is a very small species, of a dark-brown colour, with a large rufous patch at the upper part of the body, the cylindric process being of a dull yellow. It is a native of stagnant waters.

The eggs of the hydrachnæ, which are small and round, are deposited in flat clusters, sometimes on the bodies of the napæ, and other water insects. The young, when first excluded, are furnished with six legs only, but after the first and second change of their skins, become eight legged insects.

HYDRARGYRUM, a name given in the pharmacopeia to mercury or quicksilver.

HYDRANGEA, a genus of the digynia order, in the decandria class of plants, and in the natural method ranking under the 13th order, succulentæ. The capsule is bilocular, birostrated, and cut round, or parting horizontally. There are three species, of which the hortensis is a very handsome and now a popular greenhouse plant.

HYDRASTIS, a genus of the polygamia order, in the polyandria class of plants, and in the natural method ranking with those of which the order is doubtful. There is neither calyx nor nectarium; there are three petals, and the berry is composed of monospermous acini. There is one species, an herb of Canada.

HYDRAULICS. The science which has for its object the motion of fluids is called hydraulics; and its immediate application is to furnish us with the means of conducting water from one situation to another, by canals or aqueducts, and to elevate it by pumps, jets-d'eaux, and other hydraulic engines, either for the purpose of ornament or use.

In treating of this subject we shall commence with the simplest principles, and shall first speak of the discharge of fluids through small apertures.

When water flows from a vessel which has a hole or aperture in the bottom, small in comparison to the width of the vessel, the water descends vertically, and the surface appears smooth, but at three or four inches from the bottom the particles turn from this direction, and proceed on all sides with a motion more or less oblique towards the aperture. The same effect takes place when water flows through an aperture laterally. The tendency of the particles towards the aperture is a necessary consequence of their perfect mobility; for they will certainly be directed towards the point where there is the least resistance, and that point is the aperture.

It is also to be observed, that in this case, at a small distance from the bottom, a kind of funnel is formed in the water, the point of which corresponds to the centre of the aperture; when, however, the water flows through a lateral orifice or aperture, there is formed only a kind of half funnel, which does not appear to commence till the surface is near touching the upper side of the hole. It is probable that the funnel begins to form itself from the first moment of the flow; but it does not become perceptible till the surface is only at a small distance from the bottom.

It appears also, that the funnel commences higher or lower, according to the width of the bottom; and that the formation of it is less prompt or less perceptible, according to the proportion of the aperture to the extent of the bottom. The funnel is also augmented by any roughness which may exist at the sides or bottom of the vessel.

Water flows out of a small hole in the bottom of a vessel with a velocity equal to that which a ponderous

body acquires in falling from a height equal to the vertical height of the surface of the fluid above the aperture.

The same law takes place in a lateral orifice; for the pressure of the fluid is equal (at the same depth) in all directions, and consequently produces the same degree of velocity. See HYDROSTATICS.

A fluid, in running out of an aperture, acquires a velocity sufficient to make it remount to a vertical height equal to that of the fluid above the aperture, in the same manner as a falling body acquires a velocity capable of making it ascend to the height from which it descended.

It is evident, from the theory of falling bodies, that if the velocity of the fluid in running through the aperture was uniformly continued, the fluid would move through a space double the height of the fluid above the aperture, in the same time that a falling body would employ in descending from that height.

The height being the same, the velocity of the fluid in running out of the orifice will always be the same, whatever the species of the fluid may be, and whatever its density. It is true, that when the fluid has more density it presses more forcibly, but then the mass is more considerable; and it is evident, that when the moving powers are proportioned to the masses which they put in motion, the velocities are equal.

The quantities of a fluid discharged in the same space of time through different orifices, supposing the vessels equally full during the whole of the experiments, are to each other as the products of the areas of the apertures by the square roots of the heights. For instance, it has been proved by experiment, that a circular orifice of an inch diameter, made in a thin vessel or partition, and under a surface of fluid four feet in height, will furnish in one minute of time, 5436 cubic inches French.

If, therefore, it was an object to ascertain how much a circular orifice of two inches diameter, under nine feet of height from the surface of the water, would furnish in the same, the following proportion must be employed (it must be observed, that the orifice of two inches is four times as great as an orifice of one inch, because the areas of circles are as the squares of their diameters):

$$1 \times \sqrt{4} : 4 \times \sqrt{9} : : 5436 : x$$

Or at length

$$2 : 12 : : 5436 : 32616$$

$$\begin{array}{r} 12 \\ \hline 2)65232 \\ \hline \end{array}$$

Therefore 32616 cubic inches of water will flow from an aperture of two inches in diameter in one minute, the orifice being made nine inches from the surface, which is supposed to be kept at that height the whole time.

If a vessel of a prismatic form is filled with water, and permitted to empty itself entirely through an orifice at the bottom, and the time that it consumes in emptying itself is observed; and if afterwards, having replenished the vessel, the water is made to flow through the same aperture, the vessel being kept full the whole time, there will run out in this second instance, during the same time that the vessel took to empty itself at first, a quantity of water, double that which runs out in the first case, in which the abstraction of the water diminishes the height, and consequently the velocity.

We often perceive water flow through lateral apertures, which, though small in comparison to the width of the reservoirs, cannot be regarded as having all their points at an equal distance from the surface of the fluid; such, for example, as the apertures through which water sometimes flows in mills. The common method of determining the quantity discharged is as follows: suppose, in the first place, the aperture to be stopped up by a plate of metal, which is perforated with a number of holes; if each of these holes is regarded as particular and insulated, the rapidity of the flow through each will be according to the correspondent height of the fluid; then if the number of holes are multiplied ad infinitum, or which will amount to the same thing, if the plate is supposed to be entirely taken away, the velocity at each point of the supposed orifice will be according to the correspondent height of the fluid; and in estimating the quantity of water discharged, some attention must be paid to the inequality of the motion: yet it must not be asserted that this reasoning is entirely conclusive. In proportion as the sum of the small holes made in the plate is small in comparison with the size of the reservoir, the portions of water which flow through each hole are forced out by the absolute weight of the column above; but the moment that the number of apertures augment ad infinitum, and the streams of water which run through them become contiguous, it cannot be clearly said that the liquid flows in the same manner as through small insulated holes; yet as this hypothesis gives a result sufficiently conformable to experiments, it may be useful to preserve it, and the more so, as it leads to very simple calculations, and in all common questions this simplicity may be preferable to the minuteness of fractional operations.

The quantity of water which issues from these apertures in a given time is not so great as their size might at first suggest, because the stream is contracted by running out of each orifice, and that contraction extends to a distance nearly equal to half the diameter of the aperture; and the diameter of the contracted stream is to the diameter of the aperture a little more than as three to four, or as three and one-sixth to four, or nineteen to twenty-four; so that its area is to that of the aperture as ten to sixteen. It is nearly the same when water flows through lateral apertures. The contraction of the stream is a proof of what has been before stated, viz. that withinside a vessel the lateral particles direct themselves towards the orifice with a motion more or less oblique; and this oblique motion may be decomposed into two forces, the one parallel to the plane of the orifice, and which contracts the stream; the other perpendicular to the same plane, and the only one which produces the efflux.

This contraction occurs also when water is made to flow through pipes, and that at the entrance of the water into the pipe, and not at its exit, where the stream preserves a cylindrical form. We shall prove that this contraction diminishes, in a sensible manner, the quantity of water which would naturally flow.

In order to ascertain these facts by experiments, many have been made. In all the following instances, the ori-

fices through which the water flowed were pierced perpendicularly through plates of copper of about one-twenty-fourth of an inch thick, and the time of each experiment is reduced to one minute.

The constant height of the water above the centre of each orifice was 11 feet 8 inches 10 lines.

		No. of cubic inches furnished in 1 min.
Expt. 1.	Through an horizontal circular orifice of $\frac{1}{2}$ inch (6 lines) diameter -	2,311
2.	Through ditto of 1 inch diameter -	9,281
3.	Through ditto of 2 inches diameter	37,203
4.	Through an horizontal rectangular orifice of 1 inch long and $\frac{3}{12}$ inch wide - - - - - -	2,933
5.	Through an horizontal square orifice of 1 inch the side - -	11,817
6.	Through ditto of 2 inches each side of the orifice - - - -	47,361
Constant height = 9 feet.		
7.	Through a lateral circular orifice of $\frac{1}{2}$ inch diameter - - - -	2,018
8.	Through ditto of 1 inch diameter -	8,135
Constant height = 4 feet.		
9.	Through a lateral circular orifice of $\frac{1}{2}$ inch diameter - - - -	1,353
10.	Through ditto of 1 inch diameter -	5,436
Constant height = $\frac{7}{12}$ inch.		
11.	Through a lateral circular orifice of 1 inch diameter - - - -	628

It follows from the preceding table,

1. That the quantities of water discharged in the same time, by different apertures, under the same height of surface in the reservoir, are to each other nearly as the areas of the apertures. Compare together the results of the second and third experiments of which the areas of the orifices are in the proportion of one to four, and it will be found that the quantities of water afforded, viz. 9281 cubic inches, 37203, inches, are very nearly in the same proportion.

2. That the quantities of water discharged in the same time through the same aperture, under different heights of surface in the reservoirs, are to each other nearly as the square roots of the corresponding heights of the water in the reservoir above the centre of the aperture. Compare together the results of the 8th and 10th experiments, where the heights of the reservoirs are nine and four feet, the square roots of which are three and two, and it will be found that the two quantities of water, 8135 cubic inches, 5436 cubic inches, which run through the same orifice of one inch diameter under the different heights of nine feet and four feet, are to each other nearly in the proportion of three to two.

3. That in general the quantities of water discharged in the same time through different apertures, under different heights of surface in the reservoirs, are to each other as the areas of the apertures are to the square roots of the heights of water in the reservoirs.

4. That in consequence of the friction, the small apertures furnish a less quantity of water in proportion than the great ones, under the same height of water in the reservoir; because, comparatively to the extent of the area in each orifice, there are more points of friction against the sides of the orifice in the small than there are in the great ones; for the circumferences do not diminish so much as the areas.

5. That of many apertures of equal areas, that of which the circumference is the least, will, on account of the friction, furnish more water than the others, under the same height of the reservoir; circular apertures are, for this reason, the most advantageous of all; for the circumference of a circle is the shortest line that can be made use of to inclose a given space, therefore there is less surface of friction relatively to the size of the area.

It is easy to perceive, that the quantity of water discharged in the table of experiments is not near so great as might be expected from the extent of the areas and the heights of the reservoirs. The quantity is in fact diminished by the friction, and still more by the contraction of the stream; for the velocity which is in proportion to the entire altitude of the fluid is not sensibly changed. Supposing, first, that the area of the stream is the same as that of the orifice; and supposing, secondly, that the stream is contracted, then the difference of the quantities afforded is as sixteen to ten; that is, supposing the area of the aperture to be diminished in the proportion of sixteen to ten, the discharge of the fluid out of vessels kept equally full may be determined with sufficient exactness. By the expression, an inch of water, is understood the quantity which flows out of a circular and lateral orifice of one inch diameter, the surface of the water being constantly kept seven-twelfths of an inch above the orifice. This is the case with the eleventh experiment in the preceding table, where it appears that the quantity of water furnished is 628 cubic inches. Mr. Mariotte, who made the same experiment, found the quantity to be a little more; but it is probable that he might commit a small error, because the experiment just cited was made, M. Brisson informs us, with the utmost care and attention. A (French) pint of water, he adds, instead of weighing two pounds, as is commonly believed, is proved to fall short of that weight considerably, as will be evident by strictly examining that experiment.

When additional pipes are employed, it appears,

First, That the quantity of water discharged by different additional pipes, under the same height of water in the reservoir, is proportional to the areas of the apertures, or to the squares of their diameters.

Secondly, That the quantities of water discharged through additional pipes of the same diameter, under different altitudes of water in the reservoir, are proportional to the square root of the altitude.

Thirdly, That in general the quantities of water discharged in the same space of time through different additional pipes, under different heights of water in the reservoir, are to each other nearly as the product of the square of the diameters of the pipes by the square root of the altitude of the reservoirs.

The efflux of water, therefore, through additional pipes, follows the same laws as water when discharged through apertures made in thin substances.

If the vessel AB (Plate LXXI. Hydrostatics, &c. fig. 1.) is full of water, and the horizontal pipe D in the middle of its side, and the semicircle NEC described upon D, as a centre, with the radius, or semidiameter DC, or

DN, the perpendicular DE to the diameter CDN, is the longest that can be drawn from any part of the diameter to the circumference: and if the vessel be kept full, the jet will spout from the pipe D to the horizontal distance MN, which is double the length of the perpendicular DE. If two other pipes, as F and G, be fixed into the side of the vessel, at equal distances above and below the pipe D, the perpendiculars FH and GI, from these pipes to the semicircle will be equal; and the jets spouting from them, will each go to the horizontal distance NK, which is double the length of either of the perpendiculars FH or GI.

Fluids, by their pressure, may be conveyed over hills and valleys, in bended pipes, to any height not greater than the level of the springs whence they flow. This the ancients were ignorant of; and therefore they usually built aqueducts (vast rows of arches, one above another, between two hills, at an immense expense of money, time, and labour) in order to convey water over them, across the valley.

This is now done to equal advantage, and at much less expense, by a range of pipes laid down one hill and up the other. If water is poured into one of the legs of the bended pipe ACB (fig. 2.) it will rise exactly to the same level in the other. The reason is obvious: in the leg A there are, suppose, two ounces of water, endeavouring by the force of gravity to descend with the force of two; this will thurst forward, buoy up and support an equal quantity of a like fluid in B; and the bottom of the machine C, against which both sides equally bear, will of consequence sustain a double pressure, or that of four ounces; and in the present case, will pretty well represent the prop, or fixed point, of a balance-beam; as the equal fluid columns AC and BC, may be admitted to denote equal weights, suspended on the balance-arms, counterpoising each other: so that the rise of fluids to their first level, thus considered, is a case truly statical; and all their other motions proceed only from weight added.

We have seen, that water will rise through bended pipes to the same level as the reservoir from which it proceeds. Upon the same principle, jets, or fountains, are formed; for if near the bottom of the vessel AB (fig. 1.) you fasten a small pipe *m*, bending upwards, the water will spout out through the pipe, and rise nearly as high as the surface of the water in the vessel. It will not rise quite so high, because it is somewhat impeded by the resistance of the air, and the friction against the opening of the pipe, or adjutage.

It is always found necessary to increase the bore of the adjutage, or spouting pipe, with the height of the reservoir; for if it is too small, the rising stream will want sufficient weight and power to divide the air, which being densest near the earth, a small stream of water, endeavouring to mount to a great height, will be dashed against it with so much violence, as to fall away in a mist, and be wholly lost.

There is a certain and fit proportion to be observed between the adjutage by which the jet is delivered, and the pipe conducting it from the head. In general, about five times the diameter of the adjutage, for jets under half an inch, and six or seven times for all above, will give the size of pipes of conduct pretty well; though it will always be an error on the right side, to have them rather larger than in strictness they ought to be, that the jet may always be freely supplied with water, and in due time.

For a like reason, if there is occasion for a cock to be placed in any part of the pipe of conduct, particular care must be taken that it should be there bigger in proportion, that the water may not be pinched, but that the cavity be left at least equal to the bore of the rest of the pipe.

The bore of an adjutage cannot be too smooth, or true. Those that are cylindrical are best; those that are bored conical, worst; because of the reflections of the water from the inclined sides of the machine, which, in the hurry of the issuing stream, will in them unavoidably be made.

Archimedes' screw (fig. 7.) deserves consideration, not only for its antiquity, but its usefulness in raising water. It consists of a long cylinder, with a hollow pipe-tube, or groove, coiled about it, as represented in the figure. It is placed in a position oblique to the horizon, with the lower end in the water, the other being supported on the lower part of the winch I, by which the screw and cylinder are turned round. As soon as the screw is immersed in water, it immediately rises in the machine by the orifice C, to the level of the surface of the water E; and if the point of the helix, or spiral, which in the beginning of the motion is coincident with the surface of the water, happens not to be on the lower side of the cylinder, the water will, upon the motion of the screw, move on in the helix, until it comes to the point which is on the under side, and coincident with the watery surface: when it is arrived at that point, it cannot afterwards possess any other part of the spiral, than that which is upon the lowest part of the cylinder, for it cannot move towards H, because H is situated higher; and since this will ever be the case, after the surface of the water in the helix has attained the point E; it is plain that it must always be on the under side of the cylinder. But since the cylinder is in motion, every part of the spiral screw from EF, will by degrees succeed to the under part of the cylinder; the water therefore in the helix must succeed to every part from E to F, as it comes to the lower side; that is, it must ascend on the lower part of the cylinder through all the length of the pipe, until it comes to the orifice at top, where it will run out.

Of all the machines the ancients invented to raise water, it appears that though Archimedes' screw was the most curious, the tympanum, mentioned by Vitruvius, elevated the greatest quantity at once; a brief discription of this may suffice, as preparatory to the account of machines made in imitation of it, but more ingenious and more perfect.

The tympanum is a great hollow wheel, forming a kind of barrel or drum (as its name imports) composed of several planks joined together, well calked and pitched, and having a horizontal axle on which it turns: the interior of this drum is divided into eight equal spaces by as many partitions placed in the directions of the radii; each space or cell has an orifice of about half a foot in the rim of the drum or wheel, so shaped as to facilitate the admission of the water; moreover, there are eight hollow channels running contiguous to each other, and parallel

to the axle of the wheel, each corresponding to one of the eight large cells; into these channels the water passes out of the cells just mentioned, and after running along the channels to a convenient distance, it escapes through orifices into a reservoir placed just under the axle. Thus the water is elevated through a vertical space equal to the radius of the hollow wheel. When the tympanum is used to raise water from a running stream, it is moved by means of float boards which are impelled by the stream; but when it it employed to raise stagnant water; there is commonly a smaller wheel on the same shaft, which is turned by men walking in it, as in the old walking crane. The chief defect of this machine is that it raises the water in the most disadvantageous situation possible, for the load being found always towards the extremity of a radius of the wheel, the arm of the effective lever which answers to its increase through the whole quadrant the water describes in passing from the bottom of the wheel to the altitude of its centre; so that the power must act as if it was applied at a winch handle, and cannot therefore act uniformly.

Mr. H. Sarjeant, of Whitehaven, contrived a very cheap engine for raising water, for which the Society for the Encouragement of Arts awarded him a silver medal in the year 1801. A sketch of this simple invention is given in fig. 8.

This engine was erected at Irton-hall, which is situated on an ascent of 60 or 61 feet perpendicular height: at the foot of this elevation, about 140 yards distant from the offices, there runs a small stream of water, and in order to procure a constant supply of that necessary fluid, the object was to raise such stream to the house for culinary and domestic uses. With this view, a dam was formed at a short distance above the current, so as to cause a fall of about four feet: the water was then conducted through a wooden trough, into which a piece of leaden pipe, two inches in diameter, was inserted, and part of which is delineated at A.

The stream of this pipe is directed in such a manner as to run into the bucket B, when the latter is elevated; but as soon as it begins to descend, the stream passes over it, and flows progressively to supply the wooden trough or well, at the foot of which stands the forcing-pump C, being three inches in diameter.

D is an iron cylinder attached to the pump-rod, which passes through it: such cylinder is filled with lead, and weighs about 240 lbs. This power works the pump, and forces the water to ascend to the house through a pipe one inch in diameter, and which is 420 feet in length.

At E is fixed a cord, which, when the bucket approaches to within four or five inches of its lowest projection, extends, and opens a valve in the bottom of the vessel through which the water is discharged.

An engine in a great degree similar to this was erected some years ago by the late James Spedding, esq. for a lead mine near Keswick, with the addition of a smaller bucket which emptied itself into the larger near the beginning of its descent, without which addition it was found that the beam only acquired a libratory motion, without making a full and effective stroke.

To answer this purpose in a more simple way, Mr. Sarjeant constructed the small engine in such manner as to finish its stroke (speaking of the bucket end) when the beam comes into an horizontal position, or a little below it. By this means the lever is virtually lengthened in its descent in the proportion of the radius to the cosine, of about 30 degrees, or as seven to six nearly, and consequently its power is increased in an equal proportion.

It is evident, that the opening of the valve might have been effected, perhaps better, by a projecting pin at the bottom, but Mr. S. chose to give an exact description of the engine as it stands. It has now been some years in use, and completely answers the purpose intended.

The only artificers employed, except the plumber, were a country blacksmith and carpenter; and the whole cost, exclusive of the pump and pipes, did not amount to 5*l*. Pumps are engines depending also on the principles of hydraulics. See PUMP.

HYDRO-CARBONATES, combinations of carbon with hydrogen. A gas of this name is obtained from moistened charcoal by distillation.

HYDROCELE. See SURGERY.

HYDROCHARIS, the *little water-lily*, a genus of the enneandria order, in the diœcia class of plants, and in the natural method ranking under the first order, palmæ. The spatha of the male is diphyllous; the calyx trifid; the corolla tripetalous; the styles six; the capsule has six cells, and is polyspermous inferior. There is only one species, a native of Britain, growing in slow streams and wet ditches. It has kidney-shaped leaves, thick, smooth, and of a brownish-green colour, with white blossoms. There is a variety with double flowers, of a very sweet smell.

HYDROCOTYLE, *water-naval wort*, a genus of the digynia order, in the pentandria class of plants, and in the natural method ranking under the 45th order, umbellatæ. The umbel is simple; the involucrum tetraphyllous; the petal entire; the seeds are half round and compressed. There are 15 species, none of which are ever cultivated in gardens. One of them, a native of Britain, growing in marshy grounds, is supposed by the farmers to occasion the rot in sheep. The leaves have central leaf-stalks, with about five flowers in a rundle; the petals are of a reddish white.

HYDROGEN, in chemistry, one of the simple combustibles, the base of hydrogen gas, formerly called inflammable air.

HYDROGEN-GAS. To obtain this, put one part of iron-filings into a retort, attached to the pneumatic cistern, and pour thereon two parts of sulphuric acid previously diluted with four times its bulk of water. Immediately the mixture begins to boil or effervesce with violence, and air-bubbles rush abundantly from the beak of the retort. Allow them to escape for a little, till you suppose that the common air which previously filled the retort has been displaced by the newly generated air. Then place an inverted jar over the beak of the retort. The bubbles rush in abundantly and soon fill the jar.

It was obtained by Dr. Mayow and by Dr. Hales from various substances, and has been known long before in mines under the name of the fire-damp. But Mr. Cavendish ought to be considered as its real discoverer; since it was he who first examined it, and pointed out the

difference between it and atmospheric air, and who ascertained the greatest number of its properties.

Hydrogen gas, like air, is invisable and elastic; and capable of indefinite compression and dilatation. Its specific gravity differs according to its purity. Kirwan found it 0.00010; Lavoisier 0.000094, or about 12 times lighter than common air. All burning substances are immediately extinguished by being plunged into the gas. It is incapable therefore of supporting combustion. Small animals, when they are obliged to breathe it, die; but large animals resist its action longer. Scheele found that he could breathe it for some time without much inconvenience; but Fontana, who repeated the experiment, affirmed that this was owing to the quantity of common air contained in the lungs when he began to breathe; for on expiring as strongly as possible before drawing in the hydrogen gas, he could only make three respirations, and even these three produced extreme feebleness and oppression about the breast.

The ingenious Mr. Davy, professor of chemistry in the Royal institution, to whom we are indebted for many curious and important, but rather hazardous experiments on respiration, made chiefly upon himself, after a complete exhaustion of his lungs, found great difficulty in breathing this gas for so long as half a minute. It produced uneasy feelings in the chest, momentary loss of muscular power, and sometimes a transient giddiness.

Pilatre de Rozier publicly verified the assertions of Scheele. He breathed hydrogen gas six or seven times from a bladder without inconvenience. To demonstrate that it was really hydrogen gas which he was breathing, he made a strong inspiration, and expired the air, slowly through a long tube. On bringing a lighted taper to the end of the tube, the gas took fire, and continued to burn for some time. It was objected to him, that the gas which he breathed was diluted with common air. To show that this was not the case, he mixed together one part of common air and nine parts of hydrogen gas, and having drawn the mixture into his lungs, he threw it out the same way. On applying a taper to the tube, the whole of the gas exploded in his mouth, and almost stunned him. At first he thought that the whole of his teeth had been driven out, but fortunately he received no injury whatever.

If a phial is filled with hydrogen gas, and a lighted candle brought to its mouth, the gas will take fire, and burn gradually till it is all consumed. If the hydrogen gas is pure, the flame is of a white colour; but if the gas holds any substance in solution, which is often the case, the flame is tinged of different colours, according to the substance. It is most usually reddish, because the gas holds in solution a little charcoal. A redhot iron likewise sets fire to hydrogen gas. From my experiments it follows, that the temperature at which the gas takes fire is about 1000°.

If pure oxygen and hydrogen gas be mixed together, they remain unaltered; but if a lighted taper be brought into contact with them, or an electric spark be made to pass through them, they burn with astonishing rapidity, and produce a violent explosion. If these two gasses be mixed in the proportion of one part in bulk of oxygen gas and 2.527 parts of hydrogen gas, or more accurately 85 parts by weight of oxygen gas and 15 of hydrogen gas, they explode over water without leaving any visible residuum; the vessel in which they were contained (provided the gasses were pure) being completely filled with water. But if the explosion be made in a close vessel, there is always found instead of them a quantity of water exactly equal to them in weight. This water must be composed of these two gasses; for it did not previously exist in the vessel, and no other substance besides the gasses were introduced. Water then is composed of oxygen and hydrogen; and the combustion of hydrogen is nothing else but the act of its combination with oxygen.

When two parts (in bulk) of hydrogen gas are mixed with six parts of common air, the mixture explodes with equal violence; and after the explosion the bulk of the mixture is reduced to five parts. The whole of the hydrogen gas is consumed, and likewise all that part of the common air which consists of oxygen gas, and there is formed a quantity of water equal in weight to these two bodies. This experiment is often employed to ascertain the purity of hydrogen gas. Common air and the hydrogen gas to be examined are mixed in certain proportions in a glass tube, graduated and closed at one end; they are then fired by an electric spark. The purity of the gas is proportional to the diminution of bulk. Thus, when the bulk of a mixture of two parts of the hydrogen gas and six parts of air is diminished after the explosion to five parts, the hydrogen gas may be considered as pure; if only to six, it contains some foreign ingredients, and so on. This method of detecting the purity of hydrogen gas was first employed by Berthollet. Volta, indeed, had employed it before him; but for a different purpose.

Hydrogen gas is not sensibly absorbed by water, though left for some time in contact with it. But by artificial pressure water may be made to absorb about the third part of its bulk of that gas. The taste of the water is not sensibly altered. Mr. Paul, who first formed this compound, inform us, that it is useful in inflammatory fevers and in nervous complants, but it is injurious in dropsy.

Hydrogen gas dissolves sulphur, phosphorus, and carbon. The compounds are called sulphureted, phosphureted, and carbureted hydrogen gas. See Air, Chemistry, &c.

HYDROGENIZED *sulphurets*, certain bases combined with sulphureted hydrogen.

HYDROGRAPHY, the art of measuring and describing the sea, rivers, lakes, and canals.

With regard to the sea, it gives an account of the tides, counter-tides, soundings, bays, gulphs, creeks, &c. as also of the rocks, shelves, sands, shallows, promontories, harbours, the distance and bearing of one port from another, with every thing that is remarkable, whether out at sea or on the coast.

HYDROLEA, a genus of the digynia order, in the pentandria class of plants, and in the natural method ranking with those of which the order is doubtful. The calyx is pentaphyllous; the corolla rotaceous; the filaments at the base are cordate; the capsule is bilocular and bivalved. There are four species, herbs of the East and West Indies.

HYDROMETER, an instrument much used for determining the specific gravities of liquids. It usually consists of a hollow sphere of glass or metal B, and ba-

lanced by another *b* below, containing quicksilver, or a metallic weight. Plate LXXI. fig. 19. The larger ball has a shorter neck at C. into which is screwed the graduated stem AC, which by a small weight at A causes the instrument to descend in the fluid with part of the stem. When this instrument is swimming in the jar ILMK, the part of the fluid displaced by it will be equal in bulk to the part of the instrument under water, and equal in weight to the whole instrument. This instrument, therefore, marks the differences in the density of fluids by the place at which the surface cuts the stem as it floats, or by the proportionate addition or diminution of weight which is required to make it float at the same level in each.

Beaume's areometer is often referred to in the works of French chemists. The inventor seems to have been led to a method of making instruments of this kind, which should agree with each other by reflecting on the way in which thermometers are graduated, that is, by means of an interval between two stationary points of temperature. Thus M. Beaume' adopted two determinate densities, in order to mark an interval in the stem of his hydrometer. These were that of pure water, and that of water containing $\frac{15}{85}$ parts of its weight of pure common salt at 10° Reaumur or 57° Fahrenheit. The instrument (represented by fig. 20.) was so balanced as to sink in the water to 0 near the top of the stem. In the saline solution the latter emerged more, and a certain additional portion appeared above, which was assumed to contain 15 degrees. By means of a scale and compasses, a scale of equal degrees was thus formed, adapted to the length of the stem, and being fixed within it, at a proper height, the latter was sealed at the blow-pipe without altering the weight. It is usually constructed in two pieces, to avoid an inconvenient length; one of which serves for the lower, the other for the higher, degrees of density. The glasses may be procured from the makers of thermometers, and it is convenient to have a passage from the top quite down to the lower bulb for introducing the quicksilver, which being adjusted, may be secured there by a small morsel of cork. It is obvious that persons of ingenuity may adapt such instruments to their own purposes, by fixing on two liquids of known specific gravities to serve as the extremes of their scale, and may thus apply them to the trial of all liquids, from ether to sulphuric acid, in respect to gross differences, or for the purpose of having them of uniform strength. But the instrument is not to be depended on for those accurate reports on the specific gravity of liquids which are expected in detailing chemical experiments.

Fahrenheit contrived a more accurate metallic hydrometer, having a very slender stem, terminating in a small dish. The middle, or half-length of the stem, is distinguished by a fine line across. In this instrument every division of the stem is rejected, and it is always immersed to the line by means of weights put into the dish. Thus, as the part immersed is constantly of the same magnitude, and the whole weight of the hydrometer is known; this last weight, added to the weight in the dish, will be equal to that of the fluid, displaced by the instrument. Consequently, as the whole weight of the hydrometer and its load, when adjusted in distilled water, is to 1.000, so is the whole weight when adjusted in any other fluid, to the number expressing the specific gravity of that fluid.

Were the instrument constructed so that it should displace exactly 1.000 grains of distilled water at a mean temperature, the grains to be added or taken away for any other fluid would express the difference of the specific gravity at once. But as this would require much nicety, the weight of the instrument and its load adjusted in distilled water may be ascertained, and a set of decimal weights provided, each of which should bear the same proportion to its nominal value in grains that the whole adjusted in distilled water did to 1.000. By this, or by the former expedient, the trouble of calculation may be avoided; but those who use the instrument often will find it expedient to construct a set of tables adapted to the same purpose. See SPIRITS.

HYDRO-OXIDES, metallic oxides combined with water.

HYDROPHOBIA. See MEDICINE.

HYDROPHILUS, a genus of insects of the coleoptera order. The generic character is, antennæ clavate-perfoliate; hind legs villose, formed for swimming. The principal European species of this genus, which is not an uncommon insect in our country, is the hydrophilus piceus, perhaps the largest of the British coleoptera, if we except the lucanus cervus; measuring nearly an inch and half in length. It is entirely black, and of a smooth surface, and is particularly distinguished by the form of its thorax, which is produced beneath into a very long and sharp-pointed spine, stretching to a considerable distance down the abdomen; the hind legs are furnished on each side with strong, but very fine, hairs. It is a native of stagnant waters, where its larva is principally observed to prey on the smaller kind of water snails, and is distinguished by a particularity in the highest degree remarkable; this consists in the apparently anomalous situation of the legs, which seem, unless very accurately considered, to be placed, not beneath the thorax, as in other insects, but on the upper part, and thence to be deflected towards the sides. This uncommon appearance, however, is not owing to a real dorsal insertion of the legs, but principally to the peculiar shape and position of the head; and the deception is so much heightened by the inverted posture in which the insect generally swims and rests, that it is by no means easy, even for the most scientific observer, to divest himself of the erroneous idea before mentioned.

The larvæ of the hydrophilus are supposed to remain about two years before they change into pupæ or chrysalides. When the larva is arrived at its full growth, it secretes itself in the bank of the water it inhabits, and having formed a convenient cavity or cell, lies dormant for some time, after which it divests itself of its skin, and appears in the form of a chrysalis, in which state having continued for some time longer, it again delivers itself from its exuviæ, and appears in its complete or beetle form. When first disengaged from the skin of the chrysalis, it is of a pale colour, and very tender; but in the space of a few hours the elytra, or wing-cases, acquire a degree of strength and colour, which gradually grows more and more intense, till the animal, finding itself sufficiently strong, comes forth from its retreat, and commits itself in its new form to the waters.

The male is distinguished from the female by the structure of the fore legs, which are furnished, near the setting on of the feet, with a sort of horny, concave flap or shield; the legs of the females being destitute of this part.

The female of the hydrophilus piceus affords an example of a faculty which seems to be exercised by no other coleopterous insect, viz. that of spinning a kind of web or flattish circular case of silk, which it leaves floating on the water, and in which it deposits its eggs. This case is terminated on its upper surface by a lengthened conical process resembling a horn, of a brown colour, and of a much stronger or denser nature than the case itself, which is white. The young larvæ, as soon as hatched, make their escape from the envelopement of the case, and commit themselves to the water.

The hydrophilus caraboides is a species measuring about three quarters of an inch in length, and is of a polished black colour, and of an oval shape.

The genus hydrophilus has been greatly increased by the persevering researches of modern entomologists. Mr. Marsham enumerates 28 British species.

HYDROPHYLLAX, a genus of the monogynia order, in the tetrandria class of plants. The calyx is tetrapartite; the corolla funnel-shaped; the fruit two-edged and one-seeded. There is one species, an aquatic of the East Indies.

HYDROPHYLLUM, *water-leaf*, a genus of the monogynia order, in the pentandria class of plants, and in the natural method ranking with those of which the order is doubtful. The corolla is campanulated, with five melliferous longitudinal stria on the inside; the stigma is bifid; the capsule globose and bivalved. There are two species; the virginianum, or water-leaf of Mormus, grows naturally in Canada and many other parts of America on moist ground. The root is composed of many strong fleshy fibres, from which arise many leaves with footstalks five or six inches long, jagged into three, five, or seven lobes, almost to the mid-rib, indented on their edges. The flowers are produced in loose clusters hanging downward, are bell-shaped, and of a dirty white colour.

HYDROSCOPE, an instrument anciently used for the measuring of time. The hydroscope was a kind of water-clock, consisting of a cylindrical tube, conical at bottom: the cylinder was graduated, or marked out with divisions, to which the top of the water becoming successively contiguous, as it trickled out, the vertex of the cone pointed out the hour.

HYDROSTATICAL BALANCE, a kind of balance contrived for the easy and exact finding the specific gravities of bodies, both liquid and solid. See HYDROSTATICS.

HYDROSTATICS have for their object the weight and pressure of fluids; and in this branch of science the art of determining the specific gravities of bodies is usually included, but this we have already been under a necessity of anticipating. Archimedes, among the ancients, accomplished the most remarkable discoveries in this science. He is honoured even at this day, as the inventor of the ingenious hydrostatic process, by which the purity or baseness of a crown of gold was ascertained. Among the moderns we are indebted to Gallileo, Torricelli, Descartes, Pascal, Guglielmini, and Mariotte, for the best information on this subject; and by their experiments (which are as curious as they are decisive) we are instructed in what we may expect or fear from the power of fluids violently acted upon by the principle of gravity, and in what manner and upon what principles we may employ, for the use of man, the hydraulic machines.

It has been observed in another place (See GRAVITATION), that the propensity which bodies have of approaching towards the earth, or perhaps towards its centre, is the only cause of what we term weight or gravity, and that it is by the continual efforts which they make to obey that law, that they press upon every obstacle which impedes their progress. As fluids, like solid bodies, are impelled by their gravity, so in this case they press upon every object which opposes their fall; but from their nature they press in a different manner from solid bodies, hence arise the peculiar phenomena concerning which we are now to inquire.

Fluids are substances, the component parts of which are moveable among themselves, having scarcely any cohesion one with another, and moving independently of each other. Some philosophers have included in this definition what they term the grosser fluids, as, for example, a heap of corn, a heap of shot, of sand, &c. as well as the rarer and more elastic fluids, as common air, and all other aeriform substances. The proper objects, however, of the hydrostatic science, are those fluids which, in common language, are termed liquids, or those which always present to us a plane surface, level or parallel to the horizon.

All liquid substances are not equally so; hence it follows, that the laws of hydrostatics apply with less exactness in proportion as those substances depart from perfect fluidity. Water and oil both flow when the vessels, which contain them, are either overturned or broken; but the effusion of oil is slower than that of water, because the particles of oil have more cohesion among themselves. The most singular effects in hydrostatics principally depend, perhaps, upon the extreme minuteness of the particles of fluids, but at least upon their great mobility.

To preserve a lucid order in the consideration of this subject, it will be necessary to divide the objects of our inquiry into three branches. In the first place, therefore, we shall consider in what manner the principle of gravity acts on the particles of fluids, and the phenomena which it produces in the fluids themselves; as well as their action against the sides, the bottoms, and tops of the vessels in which they are contained. Secondly, in what manner fluids of different densities act upon each other; and thirdly, the action of fluids on bodies immersed in them.

I. In pursuing the first object of this inquiry, it may be established as an axiom:

1. That the parts of the same fluid act with respect to their weight or pressure, independently of each other.

This property arises from their having scarcely any cohesion among themselves. It is otherwise with solid bodies; their several parts adhering together they press in one common mass; hence the falling of solid bodies is productive of a different effect from that of liquids. We dread the falling of a pound of ice upon our heads, while we are much more indifferent concerning that of a pound of water. The latter, in its descent, is divided by the

resistance of the air, by which some of its parts are retarded more than others; and the swiftness of the whole mass is still more retarded by this division than it otherwise would be; for by being thus divided it requires a larger surface, which abates its effect. On the contrary, a solid body falls upon a small space, which receives its whole force. Hence it follows, that angular bodies falling upon any part of the human frame are more dangerous than flat or plane ones of the same weight, and descending from the same height.

It follows from this principle, that if an aperture is made at the bottom of a vessel full of any fluid, in order to prevent the flowing out of the liquor, it is only necessary to counteract the weight of that column of fluid which has the aperture for its base, and that to counteract that weight it is the same whether the vessel is full of liquor, or whether it contains only a column, the base of which shall be equal to the aperture at the bottom.

Let the cylindrical vessel of glass A B (Plate LXXI. Hodrostatics, fig. 9.) have a hole in the bottom at C, furnished with a cylindrical ferule of copper of an inch diameter D, which is to be stopped with a piston G, or the sucker of a pump well fitted to the ferule, and oiled, that it may yield to a moderate pressure. Let the piston be supported by a small rod G H, fastened at H to the silk which unites with the portion of the pulley, M, with which the extremity of the lever M N is furnished, and which has for its center of motion the point L. The other portion of the pulley N, which terminates the other extremity of the lever, is also furnished with lines of silk, which support the small bason or scale I. Upon the copper ferule D then fit a cylindrical tube of glass F E, the interior diameter of which is equal to that of the ferule, and its height equal to that of the vessel A B. When the apparatus is disposed in this manner, fill the tube E F with water, and continue to put small weights into the scale I, until the piston begins to rise. Afterwards take away the glass tube E F, and place the piston G in the copper ferule D, and pour water into the large vessel A B, and it will appear that the same weights as before in the bason I, will raise up the piston when the larger vessel A B is entirely full. Hence it follows that there is the same power to be counteracted, whether there rests upon the piston only a column of water of its own size, or whether the vessel A B is entirely full. Such a column, therefore, presses upon its base independently of the rest of the water contained in the vessel.

To account for this, let us suppose all the water in a vessel to be divided into several columns, 1, 2, 3, 4, 5, (fig. 10.) each composed of an equal number of parts. If the bottom of the vessel, which serves for the base and support of all the columns, is opened in *a*, the column 3, being no longer supported, will descend through the aperture, sliding between the two columns 2 and 4, which are supported by the parts of the bottom of the vessel *b* and *c*, all the moveable parts of which become (if we may use the expression) small rollers, which retard the fall only in a very slight degree. This effect is the result of the small degree of cohesion between the parts of the fluid. If the columns 1 and 2 on the one part, and 4 and 5 on the other, were composed of parts adhering together, they would retard each other in their descent during their whole length, in the same manner as a wax candle would do; and by the fall of the column 3, a void would be made between them. But as all the particles are extremely minute, moving easily upon each other, they descend when the summit of the column 3 begins to descend, having no longer any support from that side; and the superficies of the whole mass descends in the same manner, though only one of the columns caused the flow from its fall. When the parts have a degree of viscosity, as those of oily fluids, or when the mass of the flowing liquor has much more of breadth than of height, the void which the descending column leaves above it is easily perceived, for then the surface, instead of being plane and even, is hollow in the middle, and assumes a funnel-like form, because the adjacent parts do not arrive with sufficient swiftness to replace those which descend through the aperture; besides the pressure of the air above, the aperture is stronger than its resistance below.

From what has been now stated, it is easy to perceive how fluids differ from solids in the phenomena of gravitation. If the vessel A B (fig. 9.) being full of water, and the tube E F being removed, it was required to raise up the piston G; all that is necessary in this case is, to support the weight of the column of water directly above the piston, because this column can move independently of the remainder; but if the whole mass of water was converted into ice, then the mass ceasing to be a liquid, and all its parts adhering together, to raise up the piston it would be necessary to support the weight of the whole mass.

2. Fluids press equally in all directions.

In other words, they not only press from the top to the bottom like other bodies, but they also press, according to their weight, upon all bodies that oppose them in a lateral direction, and even from the bottom to the top. Hence, if a cask is filled with liquid oil, the oil will run out if an aperture is made in the side, but when it is congealed it will not run out on account of its having become a solid body, for solid bodies press only from their vertex to their base, and not laterally.

To understand properly this lateral pressure of fluids, and also that which they exert from their base towards their vertex, it is necessary to consider them as a mass of small globules deposited in a vessel, and to remember that these minute globules are not arranged regularly as upon a cord, but that very frequently one column exercises its pressure between two others, and has a propensity to displace them, as may be seen in fig. 11. where the perpendicular pressure which is made opposite to the point *d*, is directed by the lateral columns towards the sides, *e*, *f*, of the vessel, in such a manner, that if the vessel was open in those places the liquid would flow out, on account of the great mobility of its parts. It is by the same mode of reasoning, that the pressure of fluids, from their base towards their vertex, is accounted for.

It is upon this principle that the water, elevated by the New River water-works, after having descended from a bason in a vertical pipe, and then after having flowed horizontally in a succession of pipes under the pavement, is raised up again, through another pipe, as high as the fountain at the Temple Garden. It is also upon this principle that a vessel may be filled either at the

mouth or at the bottom indifferently, provided that it is done through a pipe, the top of which is as high as the top of the vessel to be filled. Hence it follows, that when piers, aqueducts, reservoirs, or other hydraulic works for the retention of water are to be constructed, it becomes necessary to proportion their strength to the lateral pressure which they are likely to sustain, which becomes greater as the height of the water is more considerable. Nearly the same precautions are necessary to be taken with respect to what some philosophers call the grosser fluids, which also have a propensity to expand, as well on account of the smallness of their parts as from the small degree of cohesion which exists between them. Walls designed to support terraces ought to be sufficiently strong to resist the lateral pressure of the earth and rubbish which they are to sustain, since this pressure will be greater as the particles of earth, and of the other materials of which the terraces are composed, are less bound together, and in proportion as the terraces are more elevated.

3. All the parts of the same fluid are in equilibrium with each other, whether they are contained in one vessel or many, provided they communicate with each other; and their surfaces also are always in a plane parallel to the horizon.

This is a consequence of the principle which has been before established; for, since the particle k (fig. 11.) would be raised from the base towards the top, unless a column equal to the column $i\ k$, pressed upon it to retain it in its place; it follows that to be in equilibrium, the upper extremities of the two columns should be in the same horizontal plane, or in points equally distant from the centre of the earth; which points, however, cannot be found by a right line; for in the distance of a thousand fathoms there is about one foot difference in the perpendicular height. From this property of fluids it follows, that water conducted by pipes placed in the earth, will remount as high as the place whence it flowed, whatever the depth under ground through which it may have been conducted by the pipes. It is customary to allow half an inch of inclination in the length of six feet, to counteract the resistance produced by friction; but it is clear from what has been said, that this is not absolutely necessary, for however long the passage might be, the water would still ascend as high as the place whence it came, but it would require a little longer time to accomplish the ascent. We are enabled, upon this principle, to account for the springs which are sometimes found on the tops of mountains. Such waters flow from mountains still more elevated (whether they are far or near), by subterraneous canals. It follows from this principle, that if there are many reservoirs which communicate together, it is necessary only to see one of them to know the height of the water in the others; for it must necessarily be of the same height there as in all the rest.

From what has been observed, viz. that when all the parts of the same fluid are in equilibrium, their surfaces will also be in a plane parallel to the horizon, or, in other words, every part of the surface at an equal distance from the centre of the earth, it follows, that when the surface of water is very large, it becomes necessarily and sensibly convex. This is easily perceived at sea, where the masts of ships are observed at a distance before any other part of the ship can be distinguished.

It follows from the equal pressure of fluids in all directions, that the horizontal bottom of a vessel sustains just the pressure of a column of the fluid, whose base is the area of the bottom of the vessel, and whose perpendicular height is equal to the depth of the fluid. Thus in the vessel A B C fig. 12, the bottom B C does not sustain a pressure equal to the whole quantity of fluid contained in the vessel, but only of a column whose base is C B, and height C E. Also in the vessel F G H, the bottom G H, fig. 13, sustains a pressure equal to what it would be if the vessel were as wide at the top as bottom.

This leads us to notice what is called the hydrostatical paradox, which is thus expressed, "that a quantity of fluid, however small, may be made to counterpoise a quantity however large." Thus if to the wide vessel A B, fig. 14, the tube C D is attached, communicating with A B, and then water be poured into either of them, it will stand at the same height in both, consequently there is an equilibrium between them.

It may be thus illustrated: Let A B D G, fig. 15, represent any cylindrical vessel, to the inside of which is fitted a cover C, which will slide up and down without suffering any water to pass between the edges. In the cover is inserted a small tube, C F, which is open at top, and communicates with the inside of the cylinder beneath the cover at C. The cylinder is filled with water, and the cover put on. Then if the cover is loaded with a weight, as a pound, it will be depressed, and the water rise in the tube to E, and the weight will be sustained. If another weight be added, the water will rise to F, and the weight sustained, and so on, according to the weight added, and the length of the tube. Now the weight of the water in the tube is but a few grains, yet its lateral pressure serves to sustain as much as the weight of a column of water whose base is equal to that in the tube. Thus the column E C produces a pressure in the water contained in the cylinder, equal to what would have been produced by the column A a d D; and as this pressure is exerted equally every way, the cover will be pressed upwards with a force equal to the weight of A a d D; consequently if A a d D weigh a pound, E C will sustain a pound: and the like of any other heights and weights.

One of the most useful machines to show that a small quantity of water is capable of great pressure, is the hydrostatic bellows. This machine (fig. 16.) consists of two thick circular or oval boards, united to each other by leather, like a pair of common bellows, or a barber's puff. Into the lower board a pipe B, several feet high is fixed. Now, in showing experiments with this simple machine, which the reader might easily make, let water be poured into the pipe at its top, which will run into the bellows, and separate the boards a little: then, to show how much a small quantity of water will be able to effect by pressure, let weights be laid upon the upper board. If we pour more water into the pipe, it will as before run into the bellows, and raise up the board with all the weights upon it. And though the water in the tube should weigh in all but a single pound, yet the pressure of this small force upon the water below in the bel-

lows, will support the weights, which are perhaps a hundred pounds; nor will they have weight enough to make them descend, and conquer the weight of the water, by forcing it out of the mouth of the pipe.

Upon the principle of the upward pressure of fluids, a piece of lead may be made to swim in water, by immersing it to a proper depth, and keeping the water from getting above it. Let C D, fig. 17, be a glass tube open throughout, and G a flat piece of lead half an inch thick, fitted exactly to the lower end of the tube, but not to go within it. By means of the packthread L, the lead is held close to the bottom of the tube, and in this situation it is immersed in the water of the vessel K to somewhat more than eleven times its own thickness, because lead is more than eleven times heavier than water; then the thread L may be let go, but the lead will not fall, but be sustained by the upward pressure of the water below it. If some water be poured upon the lead, or if the tube be raised a little, the lead will fall by its own weight, which will then be too heavy for the pressure of the water round the tube, upon the column of water below it.

It is clear, from the foregoing principles, that a tun filled with water, may be burst by pressing it with some pounds additional weight of the fluid, through a tube, which may be supposed from twenty-five to thirty feet in height; for from what has been said, it necessarily follows, that the small quantity of water which the tube contains, presses upon the bottom of the tun as much as if a column of water had been added as wide as the tun itself, and as long as the tube, which would evidently be an enormous weight.

II. The effects of gravity on fluids of different densities will, from what has preceded, not be very difficult to comprehend.

It has been observed, that fluids are masses of small bodies moveable with great facility among themselves independently of each other, pressing separately, and in proportion to their masses.

It is proved also by chemical analysis, that even these minute particles are composed of particles still smaller. Now whether it results from the interposition of caloric in greater or less quantities, which we know is the cause of all fluidity, and also of the difference that exists between the incompressible and elastic fluids; or whether it may depend upon the shape or size of the particles, which, as in solid bodies, may increase or diminish the porosity, it is certain, that there is a considerable difference with respect to density in different fluids.

From this difference in point of density, a separation may be observed generally to take place, soon after mixing two heterogeneous fluids together, unless this effect is counteracted by some more powerful cause. It has been observed, that the particles, according to their weight, press independently of each other. Those therefore which have the most density, having more power to gain possession of the lower part of the vessel which contains them, oblige the others to yield and resign their situation; and hence a separation is effected. When oil and water, for instance, have been well shaken together, and afterwards the whole is left in a state of rest, the water, having more density than the oil, takes the lower position, and the oil rises to the surface. If this effect does not take place, it is owing to the intervention of one of the following causes: First, a kind of elective attraction, which may exist between the particles of different fluids, as when water and wine are mixed together, the water, though heavier than the wine, does not separate itself. Secondly, the viscosity of one of the substances, as when the whites of eggs are beaten together, and by that means a considerable quantity of air mixes with them; the air, though much lighter, has not power to disengage itself from the matter in which it is enveloped, in order to effect its escape.

If two fluids of different densities are placed in a state of equipoise with each other, and have the same base, their perpendicular heights above the horizon will be in a reciprocal ratio to their densities or specific gravities.

If, for example, mercury is put into an inverted siphon, and water is poured into one of the branches, in order to elevate the mercury in the other branch one inch above its level, it is necessary that the water should be about thirteen inches and an half high. The height of the water then will be thirteen times and a half that of the mercury; because the specific gravity of mercury is about thirteen times and a half as great as that of water.

This observation will also apply to the reciprocal action of air and water, or air and mercury upon each other. Many of the phenomena of hydrostatics and hydraulics are to be referred to the pressure of the atmosphere, for which we must refer to PNEUMATICS.

It is, however, proper on the present occasion, to call the reader's attention to some of the properties of this fluid, and he will easily remember, that as a fluid, air is possessed of gravity, and consequently presses upon all bodies which oppose it; and it is necessary to add, that like water, it presses in all directions. If, therefore, a small hole is made with a gimblet, either in the side or bottom of a cask or vessel which is quite full of liquor, it will not run out, because the external air which presses against the hole, sustains the liquor, which has not a sufficient height to overcome its pressure. Hence the necessity of a vent peg, to enable liquor to be drawn out of a full cask. The elasticity of the small quantity of air which is introduced at the vent presses the fluid, and overcomes the pressure of the air at the cock. There is an instrument in common use, called a valencia, for extracting small quantities of liquor out of the bung-holes of casks. It is a tube with a small aperture at the bottom and the top. When full, if the hole at the top is stopped with the thumb or finger, so as to prevent the pressure of the air at the top, the liquor will not run out of the hole at the bottom, being kept in by the force of the external air.

It is proper to observe, that all the effects which depend upon the pressure of air, take place in a room where the column of air is terminated by the ceiling, as well as without doors where the column of air has the whole height of the atmosphere; and the reason is, because the air in the room has a communication with that on the outside, supposing it to be only by means of the key-hole. Thus a barometer placed in a hall, will have its mercury as high as if it was placed in an open field.

The curious effects produced by siphons, all depend upon the pressure of the air.

A siphon is a bent tube, A B C, (fig. 3) made of glass, metal, &c. One branch of which A B, is shorter than the other B C. In order to make use of this instrument, place the extremity of the short branch in the vessel A, which may be supposed to contain any fluid matter, water for instance. If the air then is drawn out of the siphon (fig. 4), by means of the long branch x, the liquor will begin to flow, and will not cease while the short branch A B remains immersed in the fluid. It is easy to see that the pressure of the air upon the surface of the fluid in the vessel, is the cause of its discharge through the siphon. For suppose G F the confines of the atmosphere, all the points of the surface A of the liquor will be equally pressed by the column of air A F; if, therefore, at some point of this surface, the pressure is suspended, the liquor must flow at that point, because it finds less resistance there than in any other part; this is therefore the obvious reason why the siphon becomes full immediately after the air is drawn out at the extremity C.

If the two branches of the siphon were of equal lengths, as B A, B D, the flow through the bent tube would not take place; because the column of air D G which would resist in D, being of an equal height with that which presses at A, would also be in equilibrium with it, in the same manner as the two columns of the fluid B A, B D. But since B C, one of the legs, is longer than the other, though the column of the air G C, which answers to it, is really longer than that which presses in A; yet it is not capable of preventing the passage of the fluid. To understand this more perfectly, let us consider the column of air G C to be divided into two parts, one of which G D, would form an equipoise with the column of air F A, and would be capable of stopping the flow from the tube if the branch B C ended in D. The portion of fluid which fills the part D C of the siphon, will find no other resistance in C than one column of air D C of the same length with it, which is evidently very inferior to it in weight. This portion of fluid then flows out, because it greatly exceeds in weight the column of air which is opposed to it. But while it continues to flow, nothing sustains that which is above it, which flows necessarily, while the pressure of the air at A furnishes a new supply of fluid to replace that which runs out. It is by these means, that the water in the siphon continues to flow without intermission; because the resistance of the air in C is as much exceeded, as the length of the branch B C of the siphon exceeds that of the branch A B. In order to prove this, suppose there is added at C a tube to lengthen that branch, then it will plainly appear that in a given time more water will flow than would have been discharged without that augmentation to the branch B C.

Since it is the pressure of the air which elevates the fluid in the short branch B A, it follows, that the height of this branch is limited to thirty-two feet when the fluid is water, because the pressure of the atmosphere cannot elevate water higher; but when the liquor is mercury, the height of the short branch should not exceed thirty inches, because the atmosphere cannot sustain mercury at a greater height.

A siphon may be disguised in a cup, fig. 5, from which no liquor will flow, until it be raised above the bend of the siphon; but when the efflux once begins, it will continue to flow till the vessel be emptied. This has been called Tantalus's cup, because it is usual to place a hollow figure over the inner tube of such a length, that when the fluid has got nearly up to the lips of the figure, the siphon may begin to act, and empty the cup.

Intermitting springs, which puzzled philosophers formerly, are found to be natural siphons, which may be thus explained: Let A fig. 6, be part of a hill, within which there is a cavity B B, and from this cavity a vein, or channel running in the direction B C D. The rain that falls upon the side of the hill will sink and strain through the small pores and crevices in the hill, and fill the cavity B B with water. When the water rises to the level of C, the vein B C D will be full, and the water will run through it as a siphon, and will empty the cavity B B. It must then stop, and when the cavity is again filled, it will begin to run again.

III. The action of fluids on solid bodies immersed in them, has been treated of in SPECIFIC GRAVITY, which see.

To finish the subject of hydrostatics, however, we may add that it is evident that when a solid body is plunged into a fluid, it occupies a space in that fluid exactly equal to its own magnitude. The quantity of fluid then so displaced, either equals in density, and consequently in weight, the solid which displaced it; or, on the contrary, one of the two must weigh more than the other. In the last case, which is most common, the quantity by which the heavier body surpasses the lighter, is called the specific weight or gravity.

If a body is heavier than the fluid in which it is immersed, it is evident that it will sink to the bottom by its specific gravity. If a body is lighter than the same bulk of the fluid into which it is plunged, a part of it will swim, and the remaining part which is immersed displaces a quantity of fluid which weighs exactly as much as the whole of the solid body.

The instrument used for finding the specific gravities of bodies, is called the hydrostatic balance (fig. 18.) See SPECIFIC GRAVITY.

It differs very little from a common balance that is nicely made; only it has a hook at the bottom of one of the scales, on which different substances that are to be examined may be hung by horse-hairs, or silk threads, so as to be immersed in a vessel of water, without wetting the scale.

If a body thus suspended under the scale, at one end of the balance, be first counter-poised in air by weights in the opposite scale, and then immersed in water, the equilibrium will be immediately destroyed; then, if as much weight be put into the scale from which the body hangs, as will restore the equilibrium, without altering the weights in the opposite scale; that weight which restores the equilibrium, will be equal to the weight of a quantity of water as large as the immersed body; and if the weight of the body in air be divided by what it loses in water, the quotient will show how much that body is heavier than its bulk of water. Thus, if a guinea suspended in air, be counterbalanced by 129 grains in the opposite scale of the balance, and then, upon its being immersed in water, it becomes so much lighter as to require $7\frac{1}{4}$ grains put into the scale over it, to restore the equilibrium, it shows that a quantity of water of equal bulk with the guinea, weighs $7\frac{1}{4}$ grains, or 7.25; by which divide 129 (the

weight of the guinea in air), and the quotient will be 17.793; which shows that the guinea is 17.793 times as heavy as its bulk of water. And thus, any piece of gold may be tried, by weighing it first in air, and then in water; and if upon dividing the weight in air by the loss in water, the quotient comes out to be 17.793, the gold is good; if the quotient be 18, or between 18 and 19, the gold is very fine; but if it be less than 17, the gold is too much alloyed with other metal.

By this method, the specific gravities of all bodies that will sink in water, may be found; first weighing the body in air, then in water, and dividing the weight in air by the loss in water.

But as to those which are lighter than water, as most sorts of wood are, the following method must be taken: A sort of pincers, or tongs, must be provided, to retain the substance to be examined under water. First weigh the body in air; then having balanced the tongs in water, fix to it the body to be weighed, which being lighter than water, will raise the tongs, and cause the other scale to preponderate. Observe the loss of weight of the body in water, and proceed as before.

Their are some things that cannot be weighed in this manner, as quicksilver, fragments of diamonds, &c. which must be put into a glass bucket hanging to the scale.

HYDROSULPHURETS, in chemistry. Sulphureted or sulphurated hydrogen gas possesses the properties of an acid. It is absorbed by water, in considerable quantities, and the solution reddens vegetable blues; it combines also with alkalies and earths, and with several metallic oxides. The combinations which sulphureted hydrogen forms with bases have been called hydrosulphurets.

Sulphureted hydrogen combines with alkalies and earths, and forms with them compounds which may be distinguished by the following properties:

1. They are all soluble in water, and the solution is colourless.

2. When the solution is exposed to the air, it becomes green or greenish yellow, and deposits sulphur on the sides of the vessel in the state of a fine black crust.

3. After long exposure to the air, the solution becomes limpid and colourless; and on examination is found to contain only the sulphat of the base of the original hydrosulphuret.

4. The solution of the hydrosulphurets precipitate all metallic solutions; iron and lead, black; antimony, orange; arsenic, yellow.

The hydrosulphurets may be formed by dissolving or mixing the bases respectively with water, and causing sulphureted hydrogen gas to pass through them till they refuse to absorb any more. The excess of the gas is driven off by heating the solution. It is proper to cause the sulphureted hydrogen gas to pass through a small vessel of water before it reaches the base with which it is to combine, in order to separate any impurities with which it might be mixed. By this method solutions of the different hydrosulphurets in water may be obtained.

If these compounds be decomposed while they are colourless, by pouring upon them sulphuric acid, muriatic acid, or any other acid which does not act upon hydrogen, the sulphureted hydrogen gas exhales without the deposition of a single particle of sulphur; but if the hydrosulphuret has become yellow, some sulphur is always deposited during its decomposition, and the quantity of sulphur is proportioned to the deepness of the colour.

The yellow colour, therefore, which hydrosulphurets acquire by exposure to the atmosphere is owing to a commencement of decomposition. Part of the hydrogen of the sulphureted hydrogen abandons the sulphur, combines with the oxygen of the atmosphere, and forms water. By degrees, however, a portion of the sulphur is also converted into an acid; and when the proportion of sulphureted hydrogen is diminished, and that of the sulphur increased to a certain point, the sulphur and the hydrogen combine equally with oxygen.

If sulphuric or muriatic acids be poured upon a hydrosulphuret after it has been for some time exposed to the air, a quantity of sulphureted hydrogen gas exhales, sulphur is deposited, and after an interval of time sulphureous acid is disengaged. It is therefore sulphurous, and not sulphuric acid, which is formed while the hydrosulphuret spontaneously absorbs oxygen. This acid, however, is not perceptible till after a certain interval of time, when separated from the hydrosulphuret by means of another acid; because as long as it meets with sulphureted hydrogen a reciprocal decomposition takes place. The oxygen of the acid combines with the hydrogen of the gas, and the sulphur of both is precipitated.

The affinities of the alkalies and earths for sulphureted hydrogen appear from the experiments of Berthollet to be as follows:

Barytes,	Ammonina,
Potass,	Magnesia,
Soda,	Zirconia.
Lime,	

HYGROMETER, a machine, or instrument whereby to measure the degrees of dryness, or moisture of the atmosphere.

There are divers sorts of hygrometers; for whatever body either swells or shrinks, by dryness or moisture, is capable of being formed into an hygrometer. Such are woods of most kinds, particularly ash, deal, poplar, &c. Such also is catgut, the beard of a wild goat, &c. Stretch a hempen cord or lute string, as A B, (plate Hydrostatics, fig. 21.), along a wall, bringing it over a pulley, B; and to the other end D, fix a weight E; into which fit an index F. On the same wall fit a plate of metal H I, divided into any number of equal parts, and the hygrometer is complete. For it is known from experience that moisture sensibly shortens the length of cords or fiddle-strings; and that as the moisture evaporates, they return to their former length. The weight, therefore, in the present case, upon an increase of the moisture of the air, will ascend; and upon a diminution of the same, it will descend.

Hence, as the index F will show the spaces of ascent and descent; and those spaces are equal to the increments and decrements of the length of cord, or gut, A B D; the instrument will discover whether the air is more or less humid now, than it was at another given time.

But f a more sensible and accurate hygrometer is required, strain a whipcord or fiddle-string over several pullies, C, D, E, F, and G, fig. 22, and proceed as in

the former example. Nor does it matter whether the several parts of the cord are parallel to the horizon, as expressed in the figure, or perpendicular to the same.

The advantage of this above the former hygrometer, is, that we have a greater length of cord in the same compass; and consequently greater contraction or dilatation.

The following is much more lasting: Take a nice balance and place it in a sponge, or other body, which easily imbibes moisture, and let it be in equilibrio, with a weight hung at the other end of the beam. Now if the air become moist, the sponge becoming heavier, will preponderate; if dry, the sponge will be raised up. This balance may be contrived two ways; by either having the pin in the middle of the beam, with a slender tongue a foot and a half long, pointing to the divisions on an arched plate fitted to it; or, the other extremity of the beam may be made so long as to describe a large arch on a board placed for the purpose, as is represented in the figure.

To prepare the sponge, it may be necessary to wash it in water; and when dry again, in water or vinegar, in which sal ammoniac, or salt of tartar, has been dissolved, and let it dry again, then it is fit to be used.

A, fig. 23, represents a thin piece of sponge, so cut as to contain as large a superficies as possible. This hangs by a fine thread of silk, upon the beam B, and is exactly balanced from another thread of silk at D, strung with the smallest lead shot, at equal distances, and so adjusted as to cause the index to point at G, in the middle of the graduated arch F G H, when the air is in a middle state between the greatest moisture and the greatest dryness. I, shows a little table or shelf for that part of the silk and shot which is not suspended to rest upon.

Both Dr. Hales and Dr. Desaguliers contrived another form of sponge hygrometer, on this principle. They made an horizontal axis, having a small part of its length cylindrical, and the remainder tapering conically with a spiral thread cut in it, after the manner of the fuzee of a watch. See fig. 24. The sponge is suspended by a fine silk thread to the cylindrical part of the axis upon which it winds. This is balanced by a small weight W, suspended also by a thread, which winds upon the spiral fuzee. Then when the sponge grow sheavier, in moist weather, it descends and turns the axis, and so draws up the weight; which coming to a thicker part of the axis it becomes a balance to the sponge, and its motion is shown by an attached scale: and vice versa when the air becomes drier. Salt of tartar, or any other salt, or pot-ashes, may be put into the scale of a balance, and used instead of the sponge.

HYMEN. See Anatomy.

HYMENÆA, the bastard locust tree; a genus of the monogynia order, in the decandria class of plants; and in the natural method ranking under the 33d order, lomentaceæ. The calyx is quinquepartite; there are five petals, nearly equal; the style is intorted; the legumen full of mealy pulp. There is but one species, the courbaril, which is a large tree growing naturally in the Spanish West Indies. The trunk is covered with a light ash-coloured bark, is often more than sixty feet high, and three in diameter. The seeds are covered with a light brown sugary substance, which the Indians scrape off and eat with great avidity, and which is very agreeable. At the principal roots under ground, is found collected in large lumps a yellowish red transparent gum, which dissolved in rectified spirit of wine affords a most excellent varnish, and is the gum anime of the shops.

HYMENOPTERA, derived from ὑμην membrane and πτερον wing, in the Linnæan system of natural history, is an order of insects having four membranaceous wings, and the tails of the females are furnished with stings, which in some are used for instilling poison, and in others for merely piercing the bark and leaves of trees, and the bodies of other animals, in which they deposit their eggs.

HYOBANCHE, a genus of the angiospermia order, in the didynamia class of plants. The calyx is heptaphyllous; the corolla ringent, with no under lip. The capsule bilocular, and polyspermous. There is one species, a parasitical plant of the Cape.

HYOIDES. See Anatomy.

HYOSCYAMUS, henbane, in botany, a genus of the monogynia order, in the pentandria class of plants; and in the natural method ranking under the 28th order, luridæ. The corolla is funnel-shaped and obtuse; the stamina inclining to one side; the capsule covered and bilocular. There are eight species, one of which, viz. the niger, or common henbane, is a native of Britain. It grows on road-sides, and among rubbish. It is a biennial plant, with long fleshy roots which strike deep into the ground, sending out several large soft leaves, deeply flashed on their edges: the following spring the stalks come up, which are about two feet high, with yellow flowers standing on one side in a double row, sitting close to the stalks alternately. The seeds, leaves, and roots of this plant, as well as of all other species of this genus, are poisonous: and many well-attested instances of their bad effects are recorded; madness, convulsions, and death, being the common consequence. In a smaller dose they occasion giddiness and stupor. It is said that the leaves scattered about a house will drive away mice. The juice of the plant evaporated to an extract is prescribed in some cases as a narcotic; in which respect undoubtedly it may be a powerful medicine if properly managed. The dose is from half a scruple to half a dram. The roots are used for anodyne necklaces. Goats are not fond of the plant; horses, cows, sheep, and swine refuse it.

HYOSERIS, a genus of the polygamia æqualis order, in the syngenesia class of plants; and in the natural method ranking under the 49th order, compositæ. The receptacle is naked, the calyx nearly equal; the pappus hairy, or scarce perceptible. There are ten species, resembling dandelion.

HYOTHYROIDES. See Anatomy.

HYPALLAGE, among grammarians, a species of hyperbaton, consisting in a mutual permutation of one case for another. Thus, Virgil says, "dare classibus austros," for "dare classes austris;" and again, "necdum illis labra admovi," for "necdum illa labris admovi."

HYPECOUM, wild cummin; a genus of the digynia order, in the tetrandria class of plants; and in the natural method ranking under the 24th order, corydales. The calyx is diphyllous; the petals four; the exterior two larger and trifid; the fruit a pod. There are three

species, all of them low herbaceous plants with yellow flowers. The juice of these plants is of a yellow colour, resembling that of celandine, and is affirmed by some eminent physicians to be as narcotic as opium. From the nectarium of the blossom the bees collect great quantities of honey.

HYPERBATON, in grammar, a figurative construction inverting the natural and proper order of words and sentences. The several species of the hyperbaton are the anastrophe, the hysteron-proteron, the hypallage, synchysis, tmesis, parenthesis, and the hyperbaton, strictly so called.

Hyperbaton, strictly so called, is a long retention of the verb, which completes the sentence, as in the following example from Virgil:

> Interea *reges:* ingenti mole Latinus
> Quadrijugo vehitur curru, cui tempora circum
> Aurati bis sex radii fulgentia cingunt
> Solis avi specimen: bigis it Turnus in albis,
> Bina manu lato crispans hastilia ferro:
> Hinc pater Æneas Romanæ stirpis origo,
> Sidereo flagrans clypeo et cœlestibus armis;
> Et juxta Ascanius magnæ spes altera Romæ:
> *Procedunt* castris.

HYPERBOLA, in geometry, the section of a cone made by a plane, so that the axis of the section inclines to the opposite leg of the cone, which in the parabola is parallel to it, and in the ellipsis intersects it. The axis of the hyperbolical section will meet also with the opposite side of the cone, when produced above the vertex. See Conic Sections.

HYPERBOLE, in rhetoric, a figure, whereby the truth and reality of things are excessively either enlarged or diminished.

HYPERBOLIC Cylindroid, is a solid figure, whose generation is given by Sir Christopher Wren, in the Philosophical Transactions. Thus, two opposite hyperbolas being joined by the transverse axis, and through the centre a right line being drawn at right angles to that axis; and about that, as an axis, the hyperbolas being supposed to revolve; by such revolution, a body will be generated, which is called the hyperbolic cylindroid, whose bases, and all sections parallel to them, will be circles. In a subsequent transaction, the same author applies it to grinding of hyperbolical glasses; affirming, that they must be formed this way, or not at all. Hyperbolic leg of a curve, is that which approaches infinitely near to some asymptote. Sir Isaac Newton reduces all curves, both of the first and higher kinds, into those with hyperbolic legs, and those with parabolic ones.

Hyperbolic line is used by some authors for what we call the hyperbola itself. In this sense, the plane surface, terminated by the curve line, is called the hyperbola, or hyperbolic space; and the curve line that terminates it the hyperbolic line.

HYPERBOLOIDES, are hyperbolas of the higher kind, the nature of which is expressed by this equation: $ay^{m \times n} = bx^{m} (a + x^{n})$: especially if $m > 1$, or $n > 1$, e. g. $ay^3 = bx^2 (a + x)$.

HYPERICUM, St. John's wort; a genus of the polyndria order, in the polydelphia class of plants; and in the nateral method ranking under the 20th order, rotaceæ. The calyx is quinquepartite; the petals five; the filaments many, and coalited at the base into five pencils; the seed-vessel is a pencil. Of this genus there are 57 species, most of them hardy deciduous shrubs. The most remarkable are, 1. The hircinum, or stinking St. John's wort. Of this there are three varieties; one with strong stalks, six or eight feet high, broad leaves and large flowers; the other with strong stalks, broad leaves, and without any disagreeable odour; the third has variegated leaves. All these varieties are shrubby, and flower in June and July in such numerous clusters, that the shrubs appear covered with them; and produce abundance of seed in autumn. 2. The canariensis has shrubby stalks, and at the end of the branches, clusters of yellow flowers appearing in June and July. 3. The ascyron, or dwarf American St. John's wort, has spreading roots, sending up numerous slender square stalks, a foot long, and at the end of the stalks large yellow flowers. 4. The androsæmum, commonly called tutsan, or park-leaves, has clusters of small yellow flowers appearing in July and August, and succeeded by roundish berry-like black capsules. This grows naturally in many parts of Britain. 5. The balearicum, or water-leaved St. John's wort, is a native of Majorca, and has a shrubby stalk, with reddish scarified branches, small oval leaves warted underneath, and large yellow flowers appearing great part of the year. 6. The monogynum, or one-styled China hypericum, has a shrubby purplish stalk, about two feet high, and clusters of small yellow flowers, with coloured cups, and only one style, flowering the greatest part of the year.

The tutsan long held a place in the medicinal catalogues; but its uses are very little thought of at present. The leaves given in substance are said to destroy worms. By distillation they yield an essential oil. The flowers tinge spirits and oils of a fine purple colour. Cows, goats, and sheep eat the plant; horses and swine refuse it. The dried plant boiled in water with alum dyes yarn of a yellow colour; and the Swedes give a fine purple tinge to their spirits with the flowers.

HYPHYDRA, a genus of the class and order monoecia gynandria; the male cal. is one-leafed; cor. none; stam. six. The female no cal. or cor.; caps. one-celled. There is one species, a little aquatic plant of Guiana, of no note.

HYPNUM, feather-moss; a genus of the natural order of musci, belonging to the cryptogamia class of plants. The anthera is operculated, or covered with a lid; the calyptra smooth; the filament lateral, and rising out of a perichætium, or tuft of leaflets different from the other leaves of the plant. There are fifty species, many of them natives of Great Britain; none of them, however, have any remarkable property, except the proliferum and parietinum. The first is of a very singular structure, one shoot growing out from the centre of another: the veil is yellow and shining: the lid with a kind of long bill; the leaves not shining; sometimes of a yellowish, and sometimes of a deep green. This moss covers the surface of the earth in the thickest shades, through which the sun never shines, and where no other plant can grow. The second has shoots nearly flat and winged, undivided for a considerable length, and the leaves shining; but the

old shoots do not branch into new ones as in the preceding species. It grows in woods and shady places; and, as well as the former, is used for filling up the chinks in wooden houses.

HYPOCAUSTUM, among the Greeks and Romans, a subterraneous place, wherein was a furnace, to heat the baths.

HYPOCHÆRIS, hawk's-eye; a genus of the polygamia æqualis order, in the syngenesia class of plants; and in the natural method ranking under the 49th order, compositæ. The receptacle is paleaceous; the calyx a little imbricated; the pappus glomy. There are five species; none of which have any remarkable property, except the maculata, or spotted hawk's-eye. It is a native of Britain, and grows on high grounds. The leaves are boiled and eaten like cabbage. Horses are fond of this plant when green, but not when dry. Cows, goats, and swine eat it; sheep are not fond of it.

HYPOCHONDRIA. See ANATOMY and MEDICINE.

HYPOTHENUSE, in geometry, the longest side of a right-angled triangle; or it is that side which subtends the right angle.

Euclid, lib. I. proposition XLVII. demonstrates, that, in every rectilinear right-angled triangle, the square of the hypothenuse is equal to the squares of both the other sides.

This celebrated problem was discovered by Pythagoras, who is said to have sacrificed a hecatomb to the Muses, in gratitude for the discovery.

HYPOXIS, a genus of the monogynia order, in the hexandria class of plants; and in the natural method ranking under the 10th order, coronariæ. The corolla is divided into six parts, and persisting, superior; the capsule narrowing at the base; the calyx a bivalved glume. There are fourteen species, bulbs of America and the Cape.

HYRAX. Hyrax, a genus of quadrupeds of the glires order. The generic character is, front teeth in the upper jaw two, broad, somewhat distant; in the lower jaw four, broad, flat, twice crenated; grinders large, four on each side in both jaws; fore-feet with four toes; hind-feet with three toes; tail none; clavicles none. This genus is distinguished from all the rest of the glires by the remarkable circumstance of having four teeth in the lower jaw instead of two: these lower teeth are also of a different structure from the upper, being broad, short, and crenated or denticulated at the top: the upper teeth in this genus are also less sharp or pointed than in the rest of the glires. In other particulars the genus hyrax seems most nearly allied to that of cavia. The most remarkable species are:

1. Hyrax Capensis is a native of mountainous situations about the Cape of Good Hope; residing in the hollows of rocks, and leaping with great agility about the prominences of the irregular regions it frequents, though its general or walking pace is not remarkably quick. Its size is nearly that of a rabbit, and in colour it much resembles that animal, but is whitish beneath. It is said to be known at the Cape by the name of rock badger, but Mr. Allamand observes, that this is an improper name, since the structure of its feet evidently shows that it has no power of digging or burrowing. It is a diurnal animal, and by night retires into the cavities of rocks, &c. This animal appears to be easily tamed, and in that state is observed to be remarkably cleanly, and of a lively and active disposition; leaping almost as readily and with as much security as a cat.

2. Hyrax Syriacus, or Syrian hyrax, seems to have been first clearly described by Mr. Bruce, in the appendix to his celebrated Abyssinian Travels. It is found in Ethiopia, in the caverns of the rocks, or under the great stones in the Mountain of the Sun, behind the queen's palace at Koscam. It is also frequent in the deep caverns in the rock in many other parts of Abyssinia. It does not burrow or make holes, as the rat and rabbit.

In the place of holes, it seems to delight in less close, or more airy places, in the mouths of caves, or clefts in the rock. They do not stand upright upon their feet, but seem to steal along as in fear, their belly being nearly close to the ground, advancing a few steps at a time, and then pausing. They have something very mild, feeble, and timid, in their deportment; are gentle and easily tamed, though, when roughly handled at the first, they bite very severely. The hyrax is supposed to be the animal erroneously called by our translators of the bible cuniculus, the rabit or coney. See Plate LXXIV. Nat. Hist. fig. 230.

3. Hyrax Hudsonius. Its colour is a cinereous brown, with the ends of the hairs white. It is a native of Hudson's Bay. Its size is nearly that of a common marmot; the feet are tetradactylous; of a similar form to those of the cape hyrax, but have rounded claws on all the toes.

HYSSOPUS, hyssop, a genus of the gymnospermia order, in the didynamia class of plants; the cor. has the lower lip with a small crenate segment; stam. straight, distant. There are three species; but only one of them, viz. the officinalis, or common hyssop, is cultivated for use. Besides possessing the general virtues of aromatics, they have been supposed useful in humoral asthmas, coughs, and other disorders of the lungs; and are said to promote expectoration.

HYSTERICS. See MEDICINE.

HYSTRIX. Porcupine, a genus of quadrupeds, of the order glires. The generic character is front-teeth two, both in the upper and under jaw, obliquely cut; grinders eight; body covered with spines intermixed with hairs; four toes on the fore-feet; five on the hind.

1. Common porcupine. From their obvious external characters alone, without reference to the form and disposition of the teeth, the porcupine and the hedgehog might be placed together; but such is the dissimilarity of these organs, that the one must of necessity belong to the Linnæan order feræ, and the other to that of glires.

The singular appearance of the porcupine, so different from that of the generality of quadrupeds, must in the earliest ages have attracted the attention even of the most incurious; the variegated spines or quills with which it is covered, naturally suggesting the idea of a fierce and formidable animal: it is, however, of a harmless nature, and the quills are merely defensive weapons, which, when disturbed or attacked, the animal erects, and thus endeavours to repel his adversary.

The general length of the porcupine is about two feet from head to tail, and that of the tail about four inches. The upper parts of the animal are covered with long, hard, and sharp quills; those towards the middle and

hind part of the body being longer than the rest, and measuring from nine or ten to twelve or fifteen inches in length: they are very sharp-pointed, and are variegated with several alternate black and white rings: the root, or point of attachment, is small: the head, belly, and legs, are covered with strong dusky bristles, intermixed with softer hairs: on the top of the head the hairs are very long, and curved backwards in the manner of a ruff or crest: the ears are short and rounded: the nose blunt; the upper lip divided by a strongly-marked furrow; the two fore-teeth, both above and below, extremely large and strong: the fore feet have four toes; the hind feet five; all armed with strong crooked claws: the tail is covered with short and rather flattish quills, which are often abrupt or truncated, rather than pointed at the extremities. This animal is a native of Africa, India, and the Indian islands: it is also found in some of the warmer parts of Europe, and is said to be not very uncommon in Italy and Sicily; but is supposed to have been originally imported into those parts of Europe from other regions.

The power of darting its quills with great violence, and to a considerable distance, so confidently ascribed to the porcupine, has been doubted; but it is surely not improbable that the porcupine possessing, like other quadrupeds, the power of corrugating or shaking the general skin of its body, may sometimes by this motion cast off a few of its loose quills to some distance, and thus slightly wound any animal that may happen to stand in its way; and this may have given rise to the popular idea of its darting them at pleasure against its enemies. That it really does cast them off occasionally with some degree of violence there is no reason to doubt. The strongest and shortest of the quills are most easily detached, and are those which the animals dart against the hunters, by shaking their skin as dogs do when they come out of the water.

The porcupine feeds principally on roots, fruits, barks, and other vegetable substances: it inhabits holes or subterraneous retreats, which it is said to form into several compartments or divisions, leaving only a single hole or entrance. It sleeps much by day, and makes its excursions for food during the night. The female produces two young at a birth, and these, if taken early, are said to be easily tamed.

The porcupine admits of considerable variety as to the length and proportion of the quills in different specimens and from different countries: the long crested bristles on the back of the head, in particular, are much more conspicuous in some than in others. See Plate LXXIV. Nat. Hist. fig. 231.

2. Hystrix prehensilis, is an American species, and is found in many of the hotter parts of that continent; particularly in Brazil, where it inhabits woods, and climbs trees; clinging occasionally to the branches by its tail, in the manner of some of the opossums and monkies. It is said to feed not only on fruits of various kinds, but also on birds. It sleeps during the greater part of the day, concealing itself in the hollows of trees, or beneath their roots. Its voice, according to Marcgrave, resembles the grunting of a pig. Its general length is about a foot, and the tail about eighteen inches. The whole animal, except on the belly and insides of the limbs, is covered with short, strong, and very sharp spines, of which the longest measure three inches, and are white, barred towards the points with black. The colour of the hair with which the under parts are covered is a dusky brown. The head is small; the nose extremely blunt; and the teeth very large and strong: the ears short, moderately large, and rounded; the feet have four toes each, with strong claws, and a tubercle in place of a fifth toe; the tail is covered with spines for about a third part of its length; the remainder being nearly naked; and strongly prehensile.

3. Hystrix Mexicana. The Mexican porcupine, which is placed as a variety of the hystrix prehensilis in the Gmelinian edition of the Systema Naturæ, seems to be justly considered by Mr. Pennant as a distinct species. It is as large, according to Hernandes, as a middle-sized dog, and is of a dusky brown colour, with very long bristles intermixed with the fur. This animal inhabits the hilly parts of Mexico, residing in woods, and feeding, like the former, on fruits, &c. It is said to be easily tamed.

4. Hystrix macroura. The iridescent porcupine is an animal of a very extraordinary appearance. It is of a very thick form, and is coated with short, stiff, needle-like bristles, or small spines, which, according to the different directions of the light, exhibit changeable colours, appearing either of a gilded green, or of a reddish tinge. If we except the gilded, or cape mole, it seems to be almost the only quadruped yet known with changeable-coloured hair.

5. Hystrix fasciculata is a native of Malacca. It differs from the common porcupine in several particulars, and especially in the form and length of its tail, which is naked, scaly, about a third of the length of the body, and terminated by a tuft of long flat hairs, or rather small white laminæ, resembling strips of parchment. The body measures fifteen or sixteen inches, and is consequently less than that of the European porcupine.

This species, like others of its genus (which nature seems to have provided with defensive weapons only), possesses a kind of instinctive fierceness: when approached, it stamps with its feet, and appears to inflate itself, raising and shaking its quills. It sleeps much by day, and is active only by night. It eats in a sitting posture, holding apples and other fruits between its paws, peeling them with its teeth.

6. Hystrix dorsata is a native of the northern parts of America, and is not uncommon in Canada. It is a short thick-bodied animal, approaching somewhat to the form of a beaver, and is remarkable for the length and fulness of its fur, which is soft, of a dusky brown colour, and intermixed with longer and coarser hairs with whitish tips. Edwards compares the size to that of a fox, though the shape is widely different. The spines are nearly hid in the fur, and are only visible on a close inspection: they are situated on the head and upper parts, as well as on the tail: the longest are those on the back, which measure about three inches, while those on the other parts are proportionally shorter: they are strong and sharp-pointed, and so formed as to appear, when examined with a magnifier, as if barbed at the tips with numerous, small, reversed points or prickles, and are so slightly attached to the skin as to be loosened with great ease: and the animal will sometimes purposely brush against the legs of those who disturb it, leaving several of the spines sticking in the skin.

It is said to feed principally on the bark of the juniper tree. It drinks by lapping, in the manner of a dog. It resides in holes under the roots of trees, on which, like some others of this genus, it often climbs, and is thus killed by the American Indians, who consider it as a useful article of food: they also use the quills by way of fringes, and for the purpose of ornamenting their boxes, &c.

I.

I, the ninth letter of the alphabet, used as a numeral, signifies no more than one, and stands for so many units as it is repeated times: thus, I, one; II, two; III, three, &c. and when put before a higher numeral, it subtracts itself, as IV, four; IX, nine, &c. but when set after it, so many are added to the higher numeral, as there are I's added; thus VI is 5 + 1, or six; VII, 5 + 2, or seven; VIII, 5 + 3, or eight. The ancient Romans likewise used IƆ for 500, CIƆ for 1000, IƆƆ for 5000, CCIƆƆ for 10,000, IƆƆƆ for 50,000, and CCCIƆƆƆ for 100,000. Farther than this, as Pliny observes, they did not go in their notation; but when necessary, repeated the last number, as CCCIƆƆƆ, CCCIƆƆƆ for 200,000; CCCIƆƆƆ, CCCIƆƆƆ, CCCIƆƆƆ for 300,000; and so on.

IAMBIC, in ancient poetry, a sort of verse, so called from its consisting, either wholly or in great part, of iambuses.

IAMBUS, in ancient poetry, a simple foot consisting of a short and a long syllable.

IBERIS, *sciatica cresses*, or *candy-tuft*, a genus of the siliquosa order, in the tetradynamia class of plants, and in the natural method ranking under the 39th order, siliquosæ. The corolla is regular; the two exterior petals larger than the interior ones: the silicula polyspermous, emarginated. There are 14 species. The most remarkable are: 1. The umbellata, or common candy-tuft, a well-known annual. 2. The amara, or bitter candy-tuft. 3. sempervirens, commonly called tree candy-tuft. 4. The semperflorens, with white flowers in umbels at the ends of the branches, appearing at all times of the year.

IBEX, in zoology. See Capra.

IBIS. See Tantalus.

ICE. See Water, and Cold.

Ice-house, a building contrived to preserve ice for the use of a family in the summer season. It is generally sunk some feet in the ground in a very shady situation, and covered with thatch.

ICELAND-AGATE, a precious stone met with in the islands of Iceland and Ascension, employed by the jewellers as an agate, though too soft for the purpose. It is supposed to be a volcanic product; being solid, black, and of a glassy texture. When held between the eye and the light, it is semitransparent, and greenish, like the glass bottles which contain much iron. In the islands which produce it, such large pieces are met with that they cannot be equalled in any glass-house.

ICHNEUMON *fly*, the name of a genus of flies of the hymenoptera order. The generic character is, mouth with jaws, without tongue; antennæ with more than thirty joints; abdomen in most species footstalked; piercer exserted, with a cylindric bivalve sheath. The animals of this genus provide for the support of their offspring in a manner highly extraordinary, depositing their eggs in the bodies of other living insects, and generally in those of caterpillars. These eggs in a few days hatch, and the young larvæ, which resemble minute white maggots, nourish themselves with the juices of the unfortunate animal, which however continues to move about and feed till near the time of its change to a crysalis, when the young brood of ichneumon-larvæ creep out by perforating the skin in various places, and each spinning itself up in a small oval silken case, changes into a crysalis, the whole number forming a groupe on the shrivelled body of the caterpillar which had afforded them nourishment; and after a certain period emerge in the state of complete ichneumons.

It was the want of an exact knowledge of the genus ichneumon that proved so considerable an embarrassment to the older entomologists, who having seen a brood of ichneumons proceed from the chrysalis of a butterfly, could not but conclude that the production of insects was rather a variable and uncertain operation of nature than a regular continuation of the same species. The observations however of Swammerdam, Malphigi, Roesel, and others, have long since removed the difficulties which formerly obscured the history of the insect tribe. See Plate LXXIV. Nat. Hist. figs. 232, 233. It is said there are no less than 415 species of this insect.

ICHNOGRAPHY, in perspective, the view of any thing cut off by a plane parallel to the horizon, just at the base of it. Among painters it signifies a description of images, or of ancient statues of marble and copper, of busts and semi-busts, of paintings in fresco, mosaic works, and ancient pieces of miniature.

Ichnography. See Architecture.

ICHTHYOCOLLA. See Accipenser, and Gelatina.

ICHTHYOLITHUS, in natural history, the body or parts of a fish changed into a fossil substance. Four species are enumerated. The niger is found in a black slate in the island of Sheppey, and various parts of Wales, Germany, &c. impregnated with bitumen, pyritaceous matter, or oxide of copper. The fishes resemble the eel, swordfish, cod, flat fish, perch, roach, dace, makarel, mullet, carp, &c. The albidus is found in various parts of England, on mount Libanus in Palestine, in the ecclesiastical territories of Italy, in Switzerland, Bavaria, &c. The fishes are rarely of the sea kind, but usually those that inhabit the fresh water. They are seldom found whole, but in different parts, as the head, gill-covers, and other bones, fins, tails, tendrils, or scales, in a grey slaty swinestone, or impressed on shistose marble, and sometimes penetrated with bitumen.

ICHTHYOLOGY, ἰχθυολογια, the science of fishes, or

that branch of zoology which treats of fishes. See Fish, and Comparitive Anatomy.

ICONOCLASTS, in church history, an appellation given to those persons who in the eighth century opposed image-worship, and still given by the church of Rome to all christians who reject the use of images in religious matters.

ICOSAHEDRON, in geometry, a regular solid, consisting of 20 triangular pyramids, whose vertices meet in the centre of a sphere, supposed to circumscribe it, and therefore have their height and bases equal; wherefore the solidity of one of those pyramids multiplied by 20, the number of bases, gives the solid content of the icosahedron.

If fig. 127, Plate LXXII. Miscel. be nicely drawn on pasteboard, cut half through, and then folded up neatly together, it will represent an icosahedron. See fig. 128.

To form an icosahedron, describe upon card paper 20 equilateral triangles; cut it out by the extreme edges, and cut all the other lines half-through; then fold up by these edges, and the solid will be formed. The linear edge of the icosahedron being A, then the surface will be $5A^2\sqrt{3} = 8.660\ A^2$, and the solidity $\frac{5}{6}\ A^3 \sqrt{\frac{7 + 3\sqrt{5}}{2}} = 2.1817\ A^3$.

ICOSANDRIA, from εικοσι, "twenty," and ανηρ, "a man or husband;" the name of the 12th class in Linnæus's sexual method, consisting of plants with hermaphrodite flowers, which are furnished with 20 or more stamina, that are inserted into the inner side of the calyx or petals. See Botany.

IDES, *idus*, in the ancient Roman calendar, were eight days in each month, the first of which fell on the 15th of March, May, July, and October, and on the 13th day of other months. They were reckoned backwards: thus they called the 14th day of March, May, July, and October, and the 12th of the other months, the pridie idus, or the day before the ides; the next preceding day, they called the tertio idus; and so on, reckoning always backwards, till they came to the nones. This method of reckoning time is still retained in the chancery of Rome, and in the calendar of breviary.

IGNATIA, a genus of the monogynia order, in the pentandria class of plants. The calyx is five-toothed; the corolla is long; the fruit an unilocular plum, with many seeds. There are two species, the principal of which is the amara, a native of India. The fruit of this tree contains the seeds called St. Ignatius's beans. According to some, it is from this plant that the columbo root is obtained.

IGNIS Fatuus, a common meteor, chiefly seen in dark nights about meadows, marshes, and other moist places, as also in burying-grounds, and near dung-hills. It is known among the people by the appellations, Will with a wisp, and Jack with a lantern. See Meteors.

IGNITION. See Caloric, and Chemistry.

IGNORAMUS, was formerly indorsed by the grand jury on the back of a bill, for which they did not find sufficient evidence; but now, since the proceedings were in English, they indorse "no bill," or "not a true bill," or which is the better way, "not found."

IGUANA. See Lacerta.

ILEX, *the holm or holly tree*, a genus of the tetragynia order, in the tetrandria class of plants, and in the natural method ranking under the 43d order, dumosæ. The calyx is quadridentated; the corolla rotaceous; there is no style; the berry is monospermous. There are 16 species of this genus; but the most remarkable is the aquifolium, or common holly. Of this there is a great number of varieties with variegated leaves, which are propagated by the nursery gardeners for sale. The best of these varieties are the painted-lady holly, British holly, Bradley's best holly, phyllis or cream holly, milkmaid holly, Pritchet's best holly, gold-edged hedgehog holly, Chyney's holly, glory-of-the-west holly, Broaderick's holly, Partridge's holly, Herefordshire white holly, Blind's cream holly, Longstaff's holly, Eales's holly, silver-edged hedgehog holly. All these varieties are propagated by budding or grafting them upon stocks of the common green holly.

Sheep in the winter are fed with croppings of holly. Birds eat the berries. The bark fermented, and afterwards washed from the woody fibres, makes the common birdlime. The plant makes an impenetrable fence, and bears cropping; however, it is not found in all respects to answer for this purpose equally well with the hawthorn. The wood is used in fineering, and is sometimes stained black to imitate ebony. Handles for knives, and cogs for mill-wheels, are made of it. Mr. Miller says, he has seen the floor of a room laid with compartments of holly and mahogany, which had a very pretty effect.

ILIAC Passion. See Medicine.

ILLECEBRUM, a genus of the monogynia order, in the pentandria class of plants, and in the natural method ranking under the 12th order, holoraceæ. The calyx is pentaphyllous, and cartilaginous; there is no carolla; the stigma is simple; the capsule quinquevalved, and monospermous. There are 21 species, of which the most remarkable are the paronychia and the capitatum. Both these have trailing stalks near two feet long, which spread on the ground, furnished with small leaves like those of knot-grass. The heads of the flowers come out from the joints of the stalks, having neat silvery bracteæ surrounding them, which make a pretty appearance. Their flowers appear in June, and there is generally a succession of them for at least two months; and when the autumn proves warm, they will ripen their seeds in October.

ILLICIUM, a genus of the pentagynia order, in the dodecandria class of plants, and in the natural method ranking with those of which the order is doubtful. The calyx is tetraphyllous, and deciduous: there are eight petals, and eight petaloid subulated nectaria. There are 16 stamina with bifid antheræ; the capsules are ovate, compressed, and monospermous. There are two species, viz. 1. The floridanum, with red flowers, and very odorous fruit. It is a native of China. 2. The anisatum, a native of the woods of China and Japan. The first is a very ornamental plant, and now common in our greenhouses.

ILLUMINATING, a kind of minature-painting, anciently much practised for illustrating and adorning books. Besides the writers of books, there were artists whose profession was to ornament and paint manuscripts, who were called illuminators: the writers of books first finished their part, and the illuminators embellished them with ornamented letters and paintings. We fre-

quently find blanks left in manuscripts for the illuminators, which were never filled up. Some of the ancient manuscripts are gilt and burnished in a style superior to later times. Their colours were excellent, and their skill in preparing them must have been very great.

IMAM, a name applied by the Mahometans to him who is head of the congregation in their mosques; and by way of eminence to him who has the supreme authority both in respect to spirituals and temporals.

IMBEZLE, Embezzle, signifies to steal, pilfer, or purloin, and also to waste and diminish goods, &c. entrusted to a person's charge and care. Embezzlers of wool forfeit double damages, and may be committed to the house of correction till paid; and servants embezzling their masters' goods to the value of 40*s.* are deemed guilty of felony without benefit of clergy.

IMBRICATED, among botanists, an appellation given to such leaves of plants, as are placed over one another like the tiles of a house. The term is likewise applied to some of the heart-shells, from their being ridged transversely in the same manner.

IMMEMORIAL: in a legal sense, a thing is said to be of time immemorial, or time out of mind, that was before the reign of king Edward II.

IMMERSION, in astronomy, is when a star or planet is so near the sun with regard to our observations, that we cannot see it; being enveloped and hid in the rays of that luminary. It also denotes the beginning of an eclipse of the moon, or that moment when the moon begins to be darkened, and to enter into the shadow of the earth; and the same term is also used with regard to an eclipse of the sun, when the disk of the moon begins to cover it. In this sense emersion stand opposed to immersion, and signifies the moment wherein the moon begins to come out of the shadow of the earth, or the sun begins to show the parts of his disk which were hid before. Immersion is frequently applied to the satellites of Jupiter, and especially to the first satellite; the observation of which is of so much use for discovering the longitude. The immersion of that satellite is the moment in which it appears to enter within the disk of Jupiter, and its emersion the moment when it appears to come out. The immersions are observed from the time of the conjunction of Jupiter with the sun, to the time of his opposition; and the emersions from the time of his opposition to his conjunction.

IMPALED, in heraldry: when the coats of a man and his wife who is not an heiress are borne in the same escutcheon, they must be marshalled in pale; the husband's on the right side, and the wife's on the left: and this the heralds call baron and feme, two coats impaled. See Heraldry.

IMPARLANCE, in law, a petition in court for a day to consider or advise what answer the defendant shall make to the plaintiff's action, and is the continuance of the cause till another day, or a longer time given by the court.

An imparlance is general or special; general is when it is entered in general terms, without any special clause therein; special is where the defendant desires a further day to answer. And this last imparlance is of use to plead some matters, which cannot be pleaded after a general imparlance.

It is said that imparlance was formerly from day to day, but now it is from one term to another. In case the plaintiff amends his declaration after the same is delivered or filed, the defendant may in course impart to the next term afterwards, unless the plaintiff pays costs; but if he does, and they are accepted, the defendant may not have an imparlance. Likewise the not delivering a declaration in time is sometimes the cause of imparlance; and when the plaintiff declares, yet does not proceed in three terms after, in such case the defendant may imparl to the next succeeding term. But there are divers cases wherein imparlances are not to be given: as where a person is sued by an attorney or any other privileged person of the court, in an assize, one may not imparl, except good cause be given; nor shall there be imparlance in action of special clausum fregit, &c.

IMPATIENS, the common balsam, or noli me tangere, a genus of the class and order syngensia monogamia. The calyx is two-leaved; corolla five-petalled, irregular, with a cowled nectarium; capsule superior, five-valved. There are twelve species, all annuals. The noli me tangere is indigenous to Britain, and has its specific name from the capsule shooting forth its seeds to a great distance when touched.

IMPEACHMENT, is the accusation and prosecution of a person in parliament, for treason or other crime and misdemeanor. An impeachment before the lords by the commons of Great Britain, is a presentment to the most high and supreme court of criminal jurisdiction, by the most solemn, grand inquest of the whole kingdom. A commoner cannot be impeached before the lords for any capital offence, but only for high misdemeanors; but a peer may be impeached for any crime. The articles of impeachment are a kind of bill of indictment, found by the house of commons, and afterwards tried by the lords, who are in cases of misdemeanors considered not only as their own peers, but as the peers of the whole nation. By stat. 12 and 13 W. c. 2. no pardon under the great seal shall be pleadable to an impeachment by the commons in parliament. 4 Black. 259.

In the case of Warren Hastings, in the year 1791, it was solemnly determined that impeachments do not abate by a dissolution of parliament.

Impeachment *of waste,* signifies a restraint from committing of waste upon lands and tenements; and therefore he that has a lease without impeachment of waste, has by that a property or interest given him in the houses and trees, and may make waste in them without being impeached for it, that is, without being questioned or demanded any recompence for the waste done. 11 Rep. 82.

IMPEDIMENTS in law. Persons under impediments are those within age, under coverture, non compos mentis, in prison, or beyond seas, who, by a saving in our laws, have time to claim and prosecute the right, after the impediments removed, in case of fines levied, &c.

IMPERATIVE, one of the moods of a verb, used when we would command, entreat, or advise.

IMPERATORIA, *masterwort,* a genus of the digynia order, in the pentandria class of plants, and in the natural method ranking under the 45th order, umbellatæ. The fruit is roundish, compressed in the middle, gibbous, and surrounded with a border; the petals are inflexo-

emarginated. There is but one species, viz. the ostruthium, a native of the Austrian and Stythian Alps, and other mountainous places of Italy. The plant is cultivated in gardens for the sake of its roots, which are used in medicine. The root has a flavour similar to that of angelica, and is esteemed a good sudorific. There are instances of its having cured the ague when the bark had failed. It should be dug up in winter, and a strong infusion made in wine.

IMPERFECT, something that is defective, or that wants some of the properties found in other beings of the same kind: thus mosses are called imperfect plants, because almost all the parts of fructification are wanting in them; and for the like reason is the appellation imperfect given to the fungi and submarine plants. See Moss, FUNGI, and SUBMARINE.

IMPERFECT FLOWERS, those otherwise called stamineous.

IMPERFECT NUMBERS, such whose aliquot parts, taken together, do either exceed or fall short of that whole number of which they are parts: they are either abundant or deficient.

IMPERSONAL VERB, in grammar, a verb to which the nominative of any certain person cannot be prefixed; or, as others define it, a verb destitute of the two first and primary persons.

IMPETUS, in mechanics, the force with which one body impels or strikes another.

IMPLICATION, is where the law implies something that is not declared by parties in their deeds and agreements; and when our law gives any thing to a man, it gives implicitly whatsoever is necessary for enjoying the same. 4 Black. 200.

An implied contract is such, where the terms of agreement are not expressly set forth in words, but are such as reason and justice dictate, and which therefore the law presumes that every man undertakes to perform. Id.

An implication cannot be intended by deed, unless there are apt words, but otherwise in a will. Brownl. 153.

IMPORTATION, the act of bringing goods into a country from foreign parts. It has generally been considered, that for any country to carry on a profitable trade, it is necessary that the value of the goods sent out of it should be greater than that of the articles imported: this, however, is a very erroneous axiom, unless it is understood with great limitations. All articles of merchandize, imported merely for re-exportation, and also such as are used or worked up in our own manufactures, are far from being hurtful to our commerce; and may even, in many respects, be deemed of equal profit with our own native commodities. It is therefore an excess of such importations alone as are either for mere luxury or mere necessity.

The following statement of the total value of the imports of England, in the year 1354, furnishes a curious comparison with their present magnitude.

	L.	s.	d.
1831 fine cloths, at 6*l*. per cloth, which, with the customs, come to -	11,083	12	0
397¾ hundred weight of wax, at 40*s*. per hundred weight, which, with the customs, come to - - -	815	7	5
1829½ tons of wine, at 40*s*. per ton, which, with the customs, come to	3,841	19	0
Linen-cloth, mercery, grocery, and all other wares - - - -	22,943	6	10
On which the customs were - -	285	18	3
Total - -	38,970	3	6

At this period, and for a long time after, foreigners were the principal importers of goods in that country; and as it was thought that many of them, after disposing of their merchandise here, returned with the value in money to their own country, which was deemed a serious injury, many laws were made against carrying out of the realm any gold or silver, either in coin, plate, or bullion; and merchant strangers were compelled to give security that they would lay out all the money they received for the wares they imported, in English merchandize to be exported. These injudicious restrictions have been long since done away; and excepting the prohibition of some foreign manufactures, the import trade of that country is probably as free as the regulations necessary to secure the payment of heavy duties on almost every article of trade will admit.

Total official value of the imports of Great Britain in the year 1800.

Port of London - - -	*L*18,843,172	2	10
The outports - - -	9,514,642	11	10
England - - - -	28,357,814	14	8
Scotland - - - -	2,212,790	11	8
	30,570,605	6	4

	East Indies and China.	All other parts.
In 1801	*L*5,424,441	*L*27,371,115
1802	5,794,906	25,647,412
1803	6,348,887	21,643,577
1804	5,214,621	23,986,869
1805		24,273,451

The official value of the imports of Ireland in the year 1805, was 5,982,194*l*. 19*s*. 9*d*.

IMPOSSIBLE ROOTS, in algebra. To discover how many impossible roots are contained in any proposed equation, sir I. Newton gave this rule, in his Algebra, viz: Constitute a series of fractions, whose denominators are the series of natural numbers 1, 2, 3, 4, 5, &c. continued to the number showing the index or exponent of the highest term of the equations, and their numerators the same series of numbers in the contrary order; and divide each of these fractions by that next before it, and place the resulting quotients over the intermediate terms of the equation; then under each of the intermediate terms, if its square multiplied by the fraction over it, be greater than the product of the terms on each side of it, place the sign +; but if not, the sign —; and under the first and last term place the sign +. Then will the equation have as many imaginary roots as there are changes of the underwritten signs from + to —, and from — to +. So for the equation $x^3 - 4x^2 + 4x - 6 = 0$, the series of fractions is $\frac{3}{1}, \frac{2}{2}, \frac{1}{3}$; then the second divided by the first gives $\frac{2}{6}$ or $\frac{1}{3}$, and the third divided by the second gives $\frac{1}{3}$ also; hence these quotients placed over the intermediate terms, the whole will stand thus,

$$\begin{array}{cccc} & \frac{1}{3} & \frac{1}{3} & \\ x^3 & -\ 4x^2 & +\ 4x & -\ 6. \\ + & + & - & + \end{array}$$

Now because the square of the second term multiplied by its superscribed fraction, is $\frac{16}{3}x^4$, which is greater than $4x^4$, the product of the two adjacent terms, therefore the sign + is set below the second term; and because the square of the third term multiplied by its overwritten fraction, is $\frac{16}{3}x^2$, which is less than $24x^2$, the product of the terms on each side of it, therefore the sign — is placed under that term; also the sign + is set under the first and last terms. Hence the two changes of the underwritten signs + + — +, the one from + to —, and the other from — to +, show that the given equation has two impossible roots.

When two or more terms are wanting together, under the place of the first of the deficient terms write the sign —, under the second the sign +, under the third —, and so on, always varying the signs, except that under the last of the deficient terms must always be set the sign +, when the adjacent terms on both sides of the deficient terms have contrary signs. As in the equation,

$$\begin{array}{cccccc} x^5 & +\ ax^4 & * & * & * & +\ a^5 = 0, \\ + & + & - & + & - & + \end{array}$$

which has four imaginary roots.

The author remarks, that this rule will sometimes fail of discovering all the impossible roots of an equation, for some equations may have more of such roots than can be found by this rule, though this seldom happens.

Mr. Maclaurin has given a demonstration of this rule of Newton's, together with one of his own, that will never fail. And the same has also been done by Mr. Campbell. See Phil. Trans. vols. 34 and 35.

The real and imaginary roots of equations may be found from the method of fluxions, applied to the doctrine of maxima and minima; that is, to find such a value of x in an equation, expressing the nature of a curve, made equal to y, an abscissa which corresponds to the greatest and least ordinate. But when the equation is above three dimensions, the computation is very laborious. See Stirling's Treatise on the Lines of the third Order.

IMPOSTHUME, the same with abscess. See Surgery.

IMPRESSING men. The power of impressing seamen for the sea service, by the king's commission, has been a matter of some dispute, and submitted to with great reluctance, though it has very learnedly been argued by sir Michael Foster, that the practice of impressing, and granting power to the admiralty for that purpose, is of very ancient date, and has been continued by a regular series of precedents to the present time, whence he concludes it to be part of the common law. The difficulty arises hence, that no statute has expressly declared this power to be in the crown, though many of them very strongly imply it. The stat. 2 R. II. c. 4. speaks of mariners being arrested and retained for the king's service, as of a thing well known and practised without dispute, and provides a remedy against the running away.

By stat. 2 and 3 P. and M. c. 16, if any waterman who uses the river Thames, shall hide himself during the execution of any commission for pressing for his majesty's service, he is liable to heavy penalties. By stat. 5 Eliz. c. 6. no fisherman shall be taken by the queen's commission to serve as a mariner; but the commission shall be first brought to two justices of the peace, inhabiting near the sea-coast where the mariners are to be taken, to the intent that the justices may choose out and return such a number of able bodied men as in the commission are contained to serve her majesty. And by stat. 7 and 8 W. c. 21.; 2 Anne, c. 6.; 4 and 5 Anne, c. 19.; 13 Geo. II. c. 17; especial protections are allowed to seamen in particular circumstances, to prevent them from being impressed. All which certainly imply a power of impressing to reside somewhere; and if any where, it must, from the spirit of their constitution, as well as from the frequent mention of the king's commission, reside in the crown alone. 1 Black. 419.

IMPRISONMENT, is the restraint of a man's liberty under the custody of another, and extends not only to a goal, but a house, stocks, or where a man is held in the street, or any other place; for, in all these cases, the party so restrained is said to be a prisoner so long as he has not his liberty freely to go about his business as at other times.

None shall be imprisoned but by the lawful judgment of his peers, or by the law of the land. Magna Charta.

Imprisonment, *false*. To constitute the injury of false imprisonment, two points are necessary: the detention of the person, and the unlawfulness of such detention. Every confinement of the person is imprisonment, whether it is in a common prison, or in a private house, or in the stocks, or even by forcibly detaining one in the streets. 2 Inst. 589.

By Magna Charta, no freeman shall be taken and imprisoned, but by the lawful judgment of his equals, or by the law of the land: and by the petition of right, 3 C. I. no freeman shall be imprisoned or detained without cause shown, to which he may make answer according to law. And by the 16 C. I. c. 10. if any person is restrained of his liberty, he may, upon application by his counsel, have a writ of habeas corpus, to bring him before the court of king's bench or common pleas, who shall determine whether the cause of his commitment is just, and thereupon do as to justice appertains.

For false imprisonment the law has not only decreed a punishment by fine and imprisonment, as a heinous public crime, but has also given a private reparation to the party by action at law, wherein he shall recover damages for the loss of his time and liberty. 3 Black. 127.

IMPROPER fractions. See Arithmetic, and Algebra.

IMPROPRIATION, is properly so called when a benefice ecclesiastical is in the hands of a layman; and appropriation when in the hands of a bishop, college, or religious house, though sometimes these terms are confounded. It is said there are 3845 impropriations in England.

IMPULSE, or Impulsive Force, the same with impetus. See Mechanics.

INARCHING, in gardening. See Grafting.

INCA, or Ynca, a name given by the natives of Peru to their kings, and the princess of the blood.

INCAPACITY, in the canon law, is of two kinds:

1. The want of a dispensation for age in a minor, for legitimation in a bastard, and the like: this renders the provision of a benefice void in its original. 2. Crimes and heinous offences, which annul provisions at first valid.

INCH, a well-known measure of length, being the twelfth part of a foot, and equal to three barleycorns in length.

INCIDENCE, in mechanics, denotes the direction in which one body strikes on another. See MECHANICS, and OPTICS,

INCLINATION, is a word frequently used by mathematicians, and signifies the mutual approach, tendency, or leaning, of two lines or two planes towards each other, so as to make an angle.

Inclination of a right line to a plane, is the acute angle which that line makes with another right line drawn in the plane through the point where the inclined line intersects it, and through the point where it is also cut by a perpendicular drawn from any point of the inclined plane.

Inclination of the axis of the earth, is the angle which it makes with the plane of the ecliptic; or the angle contained between the planes of the equator and ecliptic.

Inclination of a planet, is an arch of the circle of inclination comprehended between the ecliptic and the plane of a planet in its orbit. See ASTRONOMY.

The greatest inclination of Saturn, according to Kepler, is 2° 32′; of Jupiter, 1° 20′; of Mars, 1° 50′ 30″; of Venus, 3° 22′; of Mercury, 6° 54′. According to de la Hire, the greatest inclination of Saturn is 2° 33′ 30″; of Jupiter, 1° 19′ 20″; of Mars, 1° 51′; of Venus, 3° 25′ 5″; of Mercury, 6° 52′.

Inclination of a plane, in dialling, is the arch of a vertical circle, perpendicular both to the plane and the horizon, and intercepted between them. To find this, let AB (see Plate LXXII. Misc. fig. 135) be a plane inclined to the horizon HR; apply to the plane AB a quadrant DCF, so that the plummet CE may cut off any number of degrees on the limb, as EF: then the arch DE is the measure of the angle of inclination ABH; for draw BG perpendicular to HR, then because CE is parallel to BG, the angle ECF is equal to CBG; but DCF is equal to GBH, being both right angles, therefore the angle DCF — ECF, is equal to the angle GBH — CBG; that is, DCE is equal ABH.

INCLINED PLANE, in mechanics, one that makes an oblique angle with the horizon. See MECHANICS.

INCOMMENSURABLE, a term in geometry, used where two lines, when compared to each other, have no common measure, how small soever, that will exactly measure them both. And in general, two quantities are said to be incommensurable, when no third quantity can be found that is an aliquot part of both.

Such are the diagonal and side of a square; for though each of those lines has infinite aliquot parts, as the half, the third, &c. yet not any part of the one, be it ever so little, can possibly measure the other, as is demonstrated by Euclid.

INCOMMENSURABLE NUMBERS, are such as have no common divisor that will divide them both equally.

INCORRUPTIBILES, or INCORRUPTICOLÆ, in church history, heretics which had their original at Alexandria, in the time of the emperor Justinian. Their distinguishing tenet was, that the body of Jesus Christ was incorruptible from his conception, by which they meant that after and from the time he was formed in the womb of his holy mother, he was not susceptible of any change or alteration, not even of any natural and innocent passions, as hunger, thirst, &c. so that he ate without any occasion before his death, as well as after his resurrection.

INCUBUS, or NIGHT-MARE. See MEDICINE.

INCUMBENT, a clerk or minister who is resident on his benefice: he is called incumbent, because he does, or at least ought, to bend his whole study to discharge the cure of his church.

INCURVATION *of the rays of light*, their bending out of a rectilinear or straight course, occasioned by refraction.

INDEMNITY, in law, the saving harmless; or, a writing to secure one from all damage and danger that may ensue from any act. An indemnity in regard to estates is called a warranty.

INDENTED, in heraldry, is when the outline of an ordinary is notched like the teeth of a saw.

INDENTED-LINE, in fortification, the same with what the French engineers call redent; being a trench and parapet running out and in, like the teeth of a saw, and much used in irregular fortification.

INDENTURE, is a writing containing a conveyance between two or more, indented or cut unevenly, or in and out, on the top or side, answerable to another writing that likewise comprehends the same words. Formerly when deeds were more concise than at present, it was usual to write both parts on the same piece of parchment, with some words or letters written between them, through which the parchment was cut, either in a straight or indented line, in such a manner as to leave half the word on one part, and half on the other: and this custom is still preserved in making out the indentures of a fine. But at last, indenting only has come into use without cutting through any letters at all; and it seems at present to serve for little other purpose than to give name to the species of the deed. 2 Black. 294.

INDEPENDENTS, a sect of protestants in England and Holland, so called from their independency on other churches, and their maintaining that each church or congregation has sufficient power to act and perform every thing relating to religious government within itself, and is no way subject or accountable to other churches or their deputies.

The present independents differ from the presbyterians only in their church government, in being generally more attached to the doctrines distinguished by the term orthodoxy, such as original sin, election, reprobation, &c. and in administering the Lord's supper at the close of the afternoon's service. The several sects of baptists are all independents with respect to church-government; and, like them, administer the Lord's supper in the evening, whereas the presbyterians administer it after the forenoon's service.

INDETERMINATE PROBLEM, in algebra, one which is capable of an indefinite number of solutions.

INDEX, in arithmetic and algebra, shows to what power any quantity is involved, and is otherwise called exponent.

INDEX *of a logarithm*, that which shows of how many

places the absolute number belonging to a logarithm consists, and of what nature it is, whether an integer or fraction. Thus, in this logarithm 2.523421, the number 2 standing on the left hand of the point is called the index; because it shows that the absolute number, answering to the above logarithm, consists of three places: for the number is always one more than the index. If the absolute number is a fraction, then the index of the logarithm has a negative sign marked thus 2.523421.

INDEX *of a globe*, the little style or gnomon, which being fixed on the pole of the globe, and turning round with it, points out the hours upon the hour-circle. See GLOBE.

INDIAN BERRY, in commerce, &c. See COCULUS.

INDICATIVE, in grammar, the first mood or manner of conjugating a verb, by which we simply affirm, deny, or ask something; as, *amant*, they love; *non amant*, they do not love; *amantne*, do they love?

INDICTION, in chronology, a cycle of 15 years. The Roman or papal indiction, which is that used in the pope's bulls, begins on the 1st of January; and by it the popes have dated their acts ever since Charlemagne made them sovereigns. But besides this, there are other two kinds of indiction mentioned by authors, viz. that of Constantinople, beginning on the 1st of September; and the imperial or Cæsarian indication, which commenced on the 14th of September. See CYCLE.

INDICTION is also used for the convoking an ecclesiastical council or assembly.

INDICTMENT, is a written accusation of one or more persons of a crime or misdemeanor, preferred to, and presented on oath by, a grand jury. 4 Black. 302.

An indictment may be found on the oath of one witness only, unless it is for high treason, which requires two witnesses; and unless in any instance it is otherwise specially directed by acts of parliament. 2 Haw.

The sheriff of every county is bound to return to every session of the peace, and every commission of oyer and terminer, and of general goal-delivery, 24 good and lawful men, of the county, some out of every hundred, to inquire, present, do, and execute, all those things which on the part of our lord the king, shall then and there be commanded therein. As many as appear upon this pannel are sworn of the grand jury, to the amount of twelve at the least, and not more than twenty-three, that twelve may be a majority. This grand jury is previously instructed in the articles of their inquiry, by a charge from the judge on the bench. They then withdraw from the court to sit and receive indictments, which are preferred to them in the name of the king, but at the suit of any private prosecutor; and they are only to hear evidence on behalf of the prosecution: for the finding an indictment is only in the nature of an inquiry or accusation, which is afterwards to be tried or determined; and the grand jury are only to inquire upon their oaths whether there is sufficient cause to call upon the party to answer it.

It seems generally agreed, that the grand jury may not find part of an indictment true and part false; but must either find a true bill or ignoramus for the whole; and if they take upon them to find it specially or conditionally, or to be true for part only and not for the rest, the whole is void, and the party cannot be tried upon it, but ought to be indicted anew. 2 Haw. 210.

All capital crimes whatever, and all kinds of inferior crimes which are of a public nature, as misprisions, contempts, disturbances of the peace, oppressions, and all other misdemeanors whatever of a public evil example against the common law, may be indicted, but no injuries of a private nature, unless they in some degree concern the king. And generally where a statute prohibits a matter of public grievance to the liberties and security of a subject, or commands a matter of public convenience, as the repairing of the common streets of the town, &c. every disobedience of such statute is punishable, not only at the suit of the party grieved, but also by way of indictment, for contempt of the statute, unless such method of proceeding shall manifestly appear to be excluded by it. Yet if the party offending has been fined in an action brought by the party (as it is said he may in every action for doing a thing prohibited by statute), such fine is a good bar to the indictment, because by the fine the end of the statute is satisfied; otherwise he would be liable to a second fine for the same offence. 2 Inst. 55.

If several offenders commit the same offence, though in law they are several offences in relation to the several offenders, yet they may be joined in one indictment; as if several commit a robbery, or burglary, or murder. 2 H. H. 173.

No indictment for high treason, or misprision thereof (except indictments for counterfeiting the king's coin, seal, sign, or signet), nor any process or return thereupon, shall be quashed for mis-reciting, mis-spelling, false or improper Latin, unless exception concerning the same is taken and made in the respective court where the trial shall be, by the prisoner or his counsel assigned, before any evidence given in open court on such indictment; nor shall any such mis-reciting, mis-spelling, false or improper Latin, after conviction on such indictment, be any cause or stay, or arrest of judgment; but nevertheless, any judgment on such indictment shall be liable to be reversed on writ of error as formerly.

An indictment accusing a man in general terms, without ascertaining the particular fact laid to his charge, is insufficient; for no one can know what defence to make to a charge which is uncertain, nor can plead it in bar or abatement of a subsequent prosecution; neither can it appear that the facts given in evidence against a defendant on such a general accusation, are the same of which the indictors have accused him; nor can it judicially appear to the court what punishment is proper for an offence so loosely expressed. 2 Haw. 266.

It is therefore best to lay all the facts in the indictment as near to the truth as possible; and not to say, in an indictment for a small assault (for instance) wherein the person assaulted received little or no bodily hurt, that such a one, with swords, staves, and pistols, beat, bruised, and wounded him, so that his life was greatly despaired of; not to say in an indictment for a highway being obstructed, that the king's subjects cannot go thereon without manifest danger of their lives, and the like: which kind of words not being necessary, may stagger an honest man upon his oath to find the fact as so laid.

No indictment can be good without expressly showing some place wherein the offence was committed, which must appear to have been within jurisdiction of the court. 2 Haw. 236.

There are several emphatical words which the laws has

appropriated for the description of an offence, which no circumlocution will supply; as *feloniously*, in the indictment of any felony; *burglariously*, in an indictment of burglary, and the like. 2 H. H. 184.

An indictment on the black act for shooting at any person must charge that the offence was done wilfully and maliciously.

By 10 and 11 W. c. 23, it is enacted, that no clerk of assize, clerk of the peace, or other person, shall take any money of any person bound over to give evidence against a traitor or felon for the discharge of his recognizance, nor take more than 2*s*. for drawing any bill of indictment against any such felon, on pain of 5*l*. to the party grieved, with full costs. And if he shall draw a defective bill, he shall draw a new one gratis on the like penalty.

With respect to drawing indictments for other misdemeanors, not being treason or felony, no fee is limited by the statute; the same, therefore, depends on the custom and ancient usage.

Every person charged with any felony or other crime, who shall on his trial be acquitted, or against whom no indictment shall be found by the grand jury, or who shall be discharged by proclamation for want of prosecution, shall be immediately set at large in open court, without payment of any fee to the sheriff or gaoler; but in lieu thereof, the treasurer, on a certificate signed by one of the judges or justices before whom such prisoner shall have been discharged, shall pay out of the general rate of the county or district, such sum as has been usually paid, not exceeding 13*s*. 4*d*.

But an action cannot be brought by the person acquitted against the prosecutor of the indictment, without obtaining a copy of the record of his indictment and acquittal; which in prosecutions for felony it is not usual to grant, if there is the least probable cause to found such prosecution upon. For it would be a very great discouragement to the public justice of the kingdom, if prosecutors who had a tolerable ground of suspicion were liable to be sued at law whenever their indictments miscarried. But an action on the case for a malicious prosecution may be founded on such an indictment whereon no acquittal can be, as if it is rejected by the grand jury, or is coram non judice, or is insufficiently drawn; for it is not the danger of the plaintiff, but the scandal, vexation, and expense, upon which this action is founded. However, any probable cause for preferring it is sufficient to justify the defendant, provided it does not appear that the prosecution was malicious. 3 Black. 126.

INDIGOFERA, *the indigo plant*, a genus of the decandria order, in the diadelphia class of plants, and in the natural method ranking under the 32d order, papilionaceæ. The calyx is patent: the carina of the corolla furnished with a subulated patulous spur on each side; the legumen is linear. There are 35 species, the most remarkable of which is the tinctoria, a native of the warm parts of Asia, Africa, and America. This plant requires a rich soil, well tilled, and not too dry. The seed of it, which as to figure and colour, resembles gunpowder, is sown in little furrows that are about the breadth of the hoe, two or three inches deep, at a foot distance from each other, and in as straight a line as possible. Continual attention is required to pluck up the weeds, which would soon choke the plant. Though it may be sown in all seasons, the spring is commonly preferred. Moisture causes this plant to shoot above the surface in three or four days. It is ripe at the end of two months. When it begins to flower, it is cut with pruning-knives; and cut again at the end of every six weeks, if the weather is a little rainy. It lasts about two years, after which term it degenerates: it is then plucked up, and planted afresh. As this plant soon exhausts the soil, because it does not absorb a sufficient quantity of air and dew to moisten the earth, it is of advantage to the planter to have a vast space which may remain covered with trees, till it becomes necessary to fell them in order to make room for the indigo.

The valuable dye-stuff called indigo bears some faint resemblance to starch; but its properties are sufficiently peculiar to distinguish it from all other substances, and its importance entitles it to a distinguished place among vegetable principles. It is commonly procured by the following process:

When the plant has been cut down, it is placed in strata in a large wooden vessel, and covered with water. In this situation it cannot remain long in these warm climates without undergoing some change. Putrefaction, accordingly, very soon commences, or rather a kind of fermentation, which goes on best at the temperature of 80°. The water soon becomes opaque, and assumes a green colour; a smell resembling that of volatile alkali is exhaled, and bubbles of carbonic acid are emitted. When the fermentation has continued long enough, which is judged of by the paleness of the leaves, and which requires from six to twenty-four hours according to the temperature of the air and the state of the plant, the liquid is decanted off the plants into large flat vessels, where it is constantly agitated till blue floculi begin to make their appearance; water is now poured in, which causes the blue flakes to precipitate. The yellow liquid is decanted off, and the blue sediment poured into linen bags. When the water has drained from it sufficiently, it is formed into small lumps, and dried in the shade. In that state it is sold under the name of indigo.

The leaves of the indigofera yield a green infusion to hot water, and a green powder may be precipitated from it; but unless a fermentation has taken place, neither the colour nor properties of it have any resemblance to indigo.

Indigo may be obtained from the nerium tinctorium, and the isatis tinctoria or woad; a plant commonly enough cultivated in Britain, and even found wild in England. When arrived at maturity, this plant is cut down, washed, dried hastily in the sun, ground in a mill, placed in heaps, and allowed to ferment for a fortnight. It is then well mixed, and made up into balls, which are piled upon each other, and exposed to the wind and sun. In this state they become hot, and exhale a putrid ammoniacal smell. The fermentation is promoted, if necessary, by sprinkling the balls with water. When it has continued for a sufficient time, the woad is allowed to fall to a coarse powder; in which state it is sold as a dye-stuff. By treating woad nearly in the same manner with the indigofera, indigo has been obtained from it by different chemists.

Indigo is a fine light friable substance, of a deep-blue-

colour. Its texture is very compact, and the shade of its surface varies according to the manner in which it has been prepared. The principal tints are copper, violet, and blue; the lightest indigo is the best: but it is always more or less mixed with foreign substances, partly owing, doubtless, to the carelessness of the preparation, and partly to the bodies which the plant containing indigo yields to water. From the analysis of Bergman, to whom we are indebted for one of the most complete treatises on the properties of indigo which has yet appeared, the purest indigo which he could procure, was composed of the following constituents:

47	pure indigo
12	gum
6	resin
22	earth
13	oxide of iron
100.	

The earth consisted of,

10.2	barytes
10.0	lime
1.8	silica
22.0	

But in all probability the earth differs in different specimens; for Proust found magnesia in considerable quantity in the specimens which he examined. The forty-seven parts of blue pigment are alone entitled to the name of indigo; and to them therefore we shall confine our attention.

Indigo is a soft powder, of a deep blue, without either taste or smell. It undergoes no change, though kept exposed to the air. Water does not dissolve any part of it, nor produce any change upon it. Bergman, however, found that indigo, when kept long under water, underwent a kind of putrefaction, or at least exhaled a fetid odour. When heat is applied to indigo, it emits a bluish red smoke, and at last burns away with a very faint white flame, leaving behind it the earthy parts in the state of ashes.

Neither oxygen nor the simple combustibles have any effect upon indigo, except it is in a state of solution; and the same remark applies to the metallic bodies.

The fixed alkaline solutions have no action on indigo, except it is newly precipitated from a state of solution. In that case they dissolve it with facility. The solution has at first a green colour, which gradually disappears, and the natural colour of the indigo cannot again be restored. Hence we see that the alkalies when concentrated decompose indigo. Pure liquid ammonia acts in the same way. Even carbonat of ammonia dissolves precipitated indigo, and destroys its colour; but the fixed alkaline carbonats have no such effect.

Lime-water has scarcely any effect upon indigo in its usual state; but it readily dissolves precipitated indigo. The solution is at first green, but becomes gradually yellow. When the solution is exposed to the air, a slight green colour returns, as happens to the solution of indigo in ammonia; but it soon disappears. The effect of the other alkaline earths upon indigo has not hitherto been tried; but it cannot be doubted that they would act nearly as lime-water, but with more energy. The other earths seem to have but little action on indigo in any state.

The action of the acids upon indigo has been examined with most attention, and it certainly exhibits the most important phenomena.

When diluted sulphuric acid is digested over indigo, it produces no effect, except that of dissolving the impurities; but concentrated sulphuric acid dissolves it readily. One part of indigo, when mixed with eight parts of sulphuric acid, evolves heat, and is dissolved in about 24 hours. According to Haussman, some sulphurous acid and hydrogen gas are evolved during the solution. If so, we are to ascribe them to the mucilage and resin, which are doubtless destroyed by the action of the concentrated acid. The solution of indigo is well known in this country by the name of liquid blue. Bancroft calls it sulphat of indigo. While concentrated it is opaque and black; but when diluted it assumes a fine deep-blue colour; and its intensity is such, that a single drop of the concentrated sulphat is sufficient to give a blue colour to many pounds of water. Bergman ascertained the effect of different re-agents on this solution with great precision. His experiments threw light, not only on the properties of indigo, but upon the phenomena that take place when it is used as a dye-stuff. The following is the sum of these experiments:

Dropt into sulphurous acid. Colour at first blue, then green, and very speedily destroyed.—In weak tartaric acid. Becomes gradually green, and in 144 hours had assumed a very pale yellow colour. Colour not restored by alkalies.—In vinegar. Becomes green, and in four weeks the colour disappeared.—In weak potass. Becomes green, and then colourless.—In weak carbonat of potass. The same changes, but more slowly. If the solution is very weak, the colour of the indigo is not destroyed.—In ammonia and its carbonat. Colour becomes green, and then disappears.—In a weak solution of sulphat of soda. Colour after some weeks becomes green.—In tartrat of potass. Became green, and then colourless.—In a solution of sugar. Became green, and at last yellowish.—In sulphat of iron.—Colour became green, and in three weeks disappeared.—In the sulphurets. Colour destroyed in a few hours.—Realgar, white oxide of arsenic, and orpiment, produced no change.—Black oxide of manganese destroyed the colour completely.—In the infusion of madder. Colour became green, and at last yellow.—In the infusion of woad, the same changes, but more speedily.

From these experiments it is obvious that all those substances which have a very strong affinity for oxygen give a green colour to indigo, and at last destroy it. Hence it is extremely probable that indigo becomes green by giving out oxygen. Of course it owes its blue colour to that principle. This theory was first suggested by Mr. Haussman, and still farther confirmed by Berthollet. Now it is only when green that it is in a state capable of being held in solution by lime, alkalies, &c. in which state it is applied as a dye to cloth. The cloth when dipt into the vat containing it thus dissolved, combines with it, and the blue colour is restored by exposure to the atmosphere. It may be restored equally by plunging the cloth into oxy-muriatic acid. Hence the resto-

ration cannot but be ascribed to oxygen. Hence, then, the reason that sulphurous acid, the vegetable acids, sulphat of iron, give sulphat of indigo a green colour.

From these experiments we see also that the colour of indigo is destroyed by the addition of those substances which part with oxygen very readily, as the black oxide of manganese. In that case the indigo is destroyed, for its colour cannot be again restored.

Nitric acid attacks indigo with great violence, the evolution of abundance of heat, and nitrous gas. When of the specific gravity 1.52, it even sets fire to indigo. When the acid is diluted the indigo becomes brown, and crystals make their appearance, doubtless consisting of oxalic acid. What remains behind is a brown viscid substance of a very bitter taste, probably analogous to the yellow bitter principle of Welter.

Muriatic acid does not act upon indigo in its common state, but it readily dissolves indigo precipitated from the sulphat, and forms a blue coloured solution. The same phenomena are exhibited by the prosphoric, acetic, tartaric acids, and probably by all, except the acid supporters.

Oxymuriatic acid destroys the colour of indigo as readily as nitric acid, and obviously for the same reason.

Indigo is not acted upon by alcohol, ether, nor oils. The two first solvents, indeed, acquire a yellow colour when digested on common indigo by dissolving its resin.

When indigo is mixed up with bran, woad, and other similar substances, which readily undergo fermentation, it assumes a green colour during the fermentation, and is then easily dissolved by lime or potass. It is by this process that it is usually rendered proper for dyeing.

When indigo is distilled, it yields products different from any other vegetable substance, if the accuracy of Bergman, who alone has made the experiment, is to be trusted. He distilled 576 grains in a small retort connected with a pneumatic apparatus. He obtained the following products:

19	grains	carbonic acid gas
173	——	of a yellow acid liquid, containing ammonia
53	——	oil
331	——	charcoal
576.		

INDIVISIBLES, in geometry, the elements or principles into which any body or figure may be ultimately resolved; which elements are supposed infinitely small: thus a line may be said to consist of points, a surface of parallel lines, and a solid of parallel and similar surfaces; and then, because each of these elements is supposed indivisible, if in any figure a line be drawn through the elements perpendicularly, the number of points in that line will be the same as the number of the elements; whence we may see that a parallelogram, prism, or cylinder, is resolvable into elements or indivisibles, all equal to each other, parallel and like to the base; a triangle into lines parallel to the base, but decreasing in arithmetical proportion; and so are the circles which constitute the parabolic conoid, and those which constitute the plane of a circle, or surface of an isosceles cone.

A cylinder may be resolved into cylindrical curve surfaces, having all the same height, and continually decreasing inwards, as the circles of the base do on which they insist.

The method of indivisibles is only the ancient method of exhaustions, a little disguished and contracted. It is found of great use in shortening mathematical demonstrations, of which take the following instance in the famous proposition of Archimedes, viz. that a sphere is two-thirds of a cylinder circumscribing it.

Suppose a cylinder, a hemisphere, and an inverted cone (Plate LXXII. Miscel. fig. 133) to have the same base altitude, and to be cut by infinite planes all parallel to the base, of which dg is one. It is plain the square of dh will be every where equal to the square of kc (the radius of the sphere); and consequently, since circles are to one another as the squares of the radii, all the circles of the hemisphere will be equal to all those of the cylinder, deducting thence all those of the cone: wherefore the cylinder, deducting the cone, is equal to the hemisphere; but it is known that the cone is one-third of the cylinder, and consequently the sphere must be two-thirds of it.

INDORSEMENT, in law, any thing written on the back of a deed, as a receipt for money received. See Bills of Exchange.

INDUCEMENT, in law, what is alledged as a motive or incitement to a thing, and is used specially in many cases; as, there is an inducement in actions, to a traverse in pleadings, a fact or offence committed, &c.

Inducements to actions need not to have so much certainty as in other cases: a general indebitatus is not sufficient where it is the ground of the action; but where it is the inducement to the action, as in consideration of forbearing a debt till such a day (for that the parties are agreed upon the debt), this being but a collateral promise, is good without showing how due. 2 Mod. 70. An inducement to a traverse must be such matter as is good and justifiable in law. There is an inducement to a justification when what is alledged against it is not the substance of the plea. Moor. 847.

INDUCTION, in law, is the giving a clerk instituted to a benefice the actual possession of the temporalities thereof, in the nature of livery of seisin. It is performed by a mandate from the bishop to the archdeacon, who commonly issues out a precept to some other clergyman to perform it for them; which being done, the clergyman who inducts him indorses a certificate of his induction on the archdeacon's mandate, and they who were present testify the same under their hands, and by this the person inducted is in full and complete possession of all the temporalities of his church.

INDULT, in the church of Rome, the power of presenting to benefices granted to certain persons by the pope. Of this kind is the indult of kings and sovereign princes, in the Romish communion, and that of the parliament of Paris granted by several popes. By the concordat for the abolition of the pragmatic sanction, made between Francis I. and Leo X. in 1516, the French king had the power of nominating to bishoprics, and other consistorial benefices, within his realm. At the same time, by a particular bull, the pope granted him the privilege of nominating to the churches of Brittany and Provence.

INERTIA of matter, in philosophy, is defined by

sir Isaac Newton to be a passive principle by which bodies persist in their motion or rest, receive motion in proportion to the force impressing it, and resist as much as they are resisted. It is also defined by the same author to be a power implanted in all matter, whereby it resists any change endeavoured to be made in its state. See MECHANICS.

INFAMY, which extends to forgery, perjury, gross cheats, &c. disables a man to be a witness or a juror; but a pardon of crimes restores a person's credit to make him a good evidence. 2 Haw. 432.

INFANCY, *management and diseases of.* We have been induced to treat of those disorders which are peculiar to infancy separately from other affections, partly by the difference of character which such ailments assume from those of the adult periods of life, and partly by the opportunity the subject will afford of introducing some preliminary observations on the management of infants; observations which we shall endeavour to make familiar and intelligible to the heads of families, or those engaged in conducting the human frame through its more tender and dependant states of existence.

It would be altogether superfluous to urge the importance of this subject. It has been calculated that more than a fourth part of the human race die in the first year after birth; and we have nearly the same evidence that this remarkable mortality originates not in the unchangeable dispositions of nature, but principally from erroneous and perverted management!

In the first division of this article we propose, therefore, to suggest a few hints respecting infantile diet; the regulation of temperature, or external heat; clothing; air, and exercise.

PART I.

SECT. I.—*Diet of infants.*

In the proper nourishment of children we are faithfully instructed by the almost unerring counsels of nature. Where mothers are capable of suckling their offspring, this ought, in no instance, to be omitted: it is, indeed, equally a cause of astonishment and regret that such an obvious and important principle could at any time be neglected or questioned. "See the infant (says a modern writer, while addressing himself to mothers) nourished by your fluids, and brought to a certain degree of perfection while yet in the womb. See him separated from it, and then see his nourishment flowing in another channel. See the secretion and preparation of the milk, the increasing size of the breast, and the formation of the nipples. Behold the economy of the infant himself; see him instinctively taught to search for the breast, and to suck the breast; to draw his nourishment from a new source, yet still from your body, and from your fluids. Did you see this connection sufficiently, you would neither give him over to the suckling of another woman, nor would you feed him with any other substance than your own milk." Dr. Herdman on Infancy.

Dr. Buchan gives it as his opinion, that not one in a hundred of those children survives who are abandoned by their mothers, and committed to the charge of foster-parents in the earliest stages of life; and although we may deem this statement in some measure exaggerated, the reflection of its approach to truth ought to be a sufficient incitement for the appointed and professed guardians of the health and well-being of society to enter a severe and unbiassed protest against the custom to which we now refer.

For the first two or three months the nutriment of the infant ought to be received entirely from the breast of its mother. During the whole of this time its wants are almost confined to nourishment and sleep. It is, however, to be confessed that there are some, although but comparatively few, instances of inability on the part of the parent to furnish milk in due quantity or suitable quality to the requisitions of her offspring. "To the puny progeny of a puny consumptively-disposed mother I would forbid (says Dr. Beddoes) the mother's breast." Now, although we are inclined to suppose that the author just quoted has admitted too much in favour of what is termed rearing by hand (for capacity of bearing is commonly connected with a capacity of nursing children), yet, where circumstances necessarily deprive the child of its regular and more salutary nutriment, it becomes a question of moment, What is to be substituted in its place? Not by any means what the generality of hired attendants direct. As soon as an infant by its cries denotes hunger, the nurse has, for the most part, instant recourse to a mixture of bread and water (pap), which is perhaps spiced, or qualified with a little brandy. To attempt the union of oil and water would be scarcely less incongruous: it is not hazarding any thing to assert, that the major part of infantile ailments are to be attributed to the heterogeneous compounds that are early given to children; and the spicy or spirituous ingredients which are added, in order to force an artificial digestion. The necessity of the latter bears decided evidence against the propriety of the former. In no period of life, during health, ought food to be of such a quality as to require the assistance of condiments or spirits; which last are especially injurious to the assimilating organs of a new-born infant.

About half a tea-cupful of cow's milk, gently warmed, is the only food that ought to be given to a child at its birth, after which it will frequently sleep for ten hours; a symptom which, although often alarming to the obtrusive ignorance of nurses, is to be regarded as a demonstration of the proper nature of the food that has been given, and an indication of future health.

To this plan it is sometimes necessary to have recouse, even when it is the intention of the mother to suckle her child, as women who have had many children frequently have no proper secretion of milk until after the second or third day from delivery.

Before quitting this part of the subject it is proper to observe, that the custom of immediately pouring down purgatives, as if to prove to the little stranger that it has arrived in a world of physic and of evils, is, although very generally adopted, highly injudicious. The bowels do not, in general, require to be thus artificially cleansed.

With respect to the quantity and times of administering food, mothers and nurses are accustomed to err. Nothing can be more improper than to suckle or feed an infant two or three times in the course of an hour. A child judiciously regulated does not demand nourishment, even during the first months, more than once in three or

four hours; as it advances it requires feeding even less frequently, and less sleep during the day.

It has already been stated that, with the exceptions pointed out, the mother's breast ought, at least during the first two or three months, to be the sole repository and entire source of infantile nutriment. If the child is brought up by hand, cow's milk gently warmed is all the food that will be necessary for the first four or five months. After these times milk may be alternated, not by moist bread, biscuit, cakes, sugar, panadas, and gruel, but by ground rice or flour well baked; the gravy of boiled meat, which last will generally be taken with avidity; small quantities of beef-tea, or veal-jelly, and other substances of the like nature; still avoiding, unless during the actual existence of disease, and under professional direction, every article in the long list of fermented, fermenting, spicy, and spirituous materials; the withholding of which, however it may offend and alarm the nurse, will be of incalculable benefit to the child.

The time of weaning must be regulated entirely by circumstances. The process should not be abrupt, but gradual. It is very seldom advisable to refuse the breast entirely before the ninth or tenth month.

We have particularly insisted on the necessity of excluding those substances from the diet of infants which are disposed to ferment, or turn sour. A general acquaintance with the laws which regulate the existence and decomposition of such substances may be acquired with less labour than would be requisite to retain in the memory, without the aid of some connecting principle, all the individual articles which are prescribed or admitted as part of the diet in childhood and youth; and in consequence of such pleasing and easy acquisition, we should find knowledge and humanity joining issue in the joyous task of averting the artificial evils which ignorance and error have made to attach to the extremely susceptible, though not naturally unhealthy, state of the primary periods of existence. Whence does the perversity of nurses respecting the treatment of children arise? Solely from ignorance. Were they convinced that the plans which are adopted prove ultimately subversive of their intended object, they would readily consent to abandon them. "Obedience will always be more cheerful and steady after a reasonable explanation." "I have heard a variety of mothers (says Dr. Beddoes) complain that sugar, biscuit, and cakes, disagreed in the most evident manner; and yet that it was impossible, by any injunctions, to prevent the one from being made a part of the food, and the other (sugar) from being given to stop the hiccups, or produce a sensation that should suspend crying for a moment. Now it is well known that perpetually recurring complaints in the stomach and bowels arise from mere sourness; and the parties, by whose mistaken kindness, or by whose delicacy of ear they are occasioned, are perfectly informed so far. It remains only to carry their knowledge a step farther. Respecting the juice of the sugar-cane, it is a very striking particular, that the poorest sort will scarcely keep a quarter of an hour in the receiver without turning sour. This can only be *told*. The acescent nature of bread, of sugar, and of the various compositions into which bread and sugar enter, may be *shown*. For this purpose it is only necessary that a solution of sugar and water should be made into vinegar. In like manner bread and sweet cake should be placed in a heat nearly equal to that of the human body, and the servant be put to taste the infusion when it becomes acid. By an address suited to the object in view, there will surely be small difficulty in giving these simple experiments all the effect that can be desired.

"I shall very contentedly allow the childless wit to laugh at me for the whimsical idea of tutoring nursemaids in chemistry. I have a balm at hand for any wound the shafts or ridicule may inflict. Considerate parents will avail themselves of so practicable an expedient, and many little sufferers will escape the consequences of an improper regimen. And these are probably (the author might have said *certainly*) far more serious, even in respect to the future than the present. For it clearly results from a contemplation of the manner in which human feelings and ideas gain their connection, that frequent discomposure of the stomach in the morning of life may be instrumental in overcasting its meridian and its close with a cloud of misery, such as neither skill nor fortune can disperse." [Beddoes' Hygeia]. For further information on the subject of diet, consult the article MATERIA MEDICA, section Dietetics.

SEC. II.—*Of temperature, including remarks on the clothing, and likewise on the washing or bathing, of infants.*

The remarkable success with which the subject of animal temperature has been recently investigated, and the application of facts, deduced from a developement of its laws, to the living system, both in its healthy and disordered state, constitute perhaps the most material improvements in modern physiology and medical practice.

Respecting the generation and adjustment of animal heat, is it not the business of this article to inquire (see PHYSIOLOGY, and MEDICINE:) our present plan extends no farther than the statement of a few practical rules on the subject of heat and cold, absolutely necessary to be attended to by all who undertake the guardianship of infancy and childhood: "for the management of temperature is of high importance in the treatment of the infant. It runs through, and is connected with, every part of his general treatment. It is to be considered in his dress, in his covering while asleep, in his bathing or washing, in his treatment in the house as well as out of it, in his air and exercise. In short, with a competent knowledge of the management of temperature, a nurse can scarcely go wrong in any part of the general treatment of an infant." [Herdman.] It must be obvious to every one that the infant at birth necessarily undergoes a sudden and material alteration in the temperature of the medium by which, without clothing, it is surrounded. The effects which would result otherwise from this remarkable change, with respect to external warmth, are in some measure obviated by the immediate commencement of respiration. This, however, is not sufficient of itself to supply the defect of external heat. The change then must be artificially rendered as gradual and imperceptible as possible; and the infant, during the first month, ought scarcely to be exposed to any sensible degree of cold, even for the shortest period. It has been with many midwives a common practice to direct that the new-born child be immediately washed with cold water, and other irritating

substances, in order to cleanse the surface of the body previously to its being covered with clothing. All that is necessary, or even proper, is the use of warm water and sponge, without any further friction, after washing, than what is necessary completely to dry the skin; indeed the propriety of washing, or in any way cleansing, the skin of an infant at birth, has lately been denied by an author whom we have already quoted; but we think that the use of tepid water, applied with gentleness, and without any subsequent violence of friction, can in no case be objectionable, but ought always to be had recourse to.

As soon as the process is completed, the infant is to be immediately clothed; and now let the habits of the common routine of nurses and of friends be as sedulously watched, and as earnestly opposed, as in relation to its diet. If the customary mode of feeding infants has induced a long train of present and permanent evils, the manner of dressing, (and which, till of very late years, has been persisted in with all the cruel pertinacity of contumacious ignorance), has also been productive of incalculable mischief. The evil is now diminished, but is not by any means destroyed. It has happened in this, as on every other occasion where the clamour of senseless conceits has been made to silence the simple and artless dictates of nature, that the most preposterous customs have obtained. "Physicians speculated about the infant's imperfect structure at birth, about the imperfect structure of his bones, the shapeless forms of his head, and the injuries he might sustain in birth; about injuries and distortions from hurtful motions and unnatural positions. They thought the infant's body unable to support itself, and that even its own motions might destroy it. Then in came the midwives for their share of the concern. The task was theirs to model the head, and to straighten the limbs; to improve upon nature; and to support their improvements by the application of fillets, rollers, and swaddling-bands. They vied with each other who should work the work most cunningly; for, strange to tell, dexterity in working this work of cruelty was reckoned one of their most necessary and important qualifications." Dr. Herdman.

In clothing, then, nothing further is requisite than to guard against the variations of external temperature, and to preserve a genial warmth for the maintenance of functions: the fillets, rollers, and bandages, of the nursery are not useless merely, but beyond measure dangerous. They are to be entirely laid aside, as implements of torture and destruction. No pressure on any part is to be employed. A broad strip of flannel or cotton loosely folded round the body is all that is requisite, even as a bandage for the navel. A thin single cap is the whole of the covering that the head requires or should receive. The body should be enveloped with a shirt of fine cotton, made loose and easy, over which should be a covering of flannel: and in a word, the dress is to be so constructed, that the rapid motion of the circulating fluids may be preserved without the smallest impediment. It may be necessary before quitting this subject, to state, that the writer's experience has convinced him of the propriety and importance of the above regulations in regard to dress and diet, even where relationship has ensured an attentive and unprejudiced scrutiny into particulars.

But it is not as it regards clothing merely that the medium to which a young infant is exposed demands assiduous attention; much care ought to be taken in providing likewise "a fit habitation for the expected little visitor." The apartment devoted to the rearing of infants, during the first months especially, ought to be so constructed and situated as to ensure a steady, equable, and mild temperature. Small confined nurseries, where it is possible, ought to be avoided. In such apartments it is difficult to guard against the extremes of either heat or cold. An exposure to a stream or current of air, occasioned by an unsuspected breach in the window, directed on the body of a sleeping infant, has often been productive of serious injury. Dr. Beddoes directs that the air of the nursery be never suffered to fall below fifty degrees; and it is always to be carefully retained in the memory, that the deficiencies occasioned by ill-constructed buildings can never be compensated by heaping fuel on the fire; by this custom indeed not only is the air rendered impure, but the temperature of the room is made still more irregular, and the danger of colds consequently increased.

There is one caution which is especially necessary with respect to the management and economy of nurseries. All occasions and sources of *damp* should most assiduously be guarded against. This caution is the more needful, because the danger from this source appears to be the least understood or suspected. It is not uncommon to observe that parents and nurses who would dread the opening of a sash-window, at the same time unwittingly expose themselves and their charge to a much greater degree of cold by permitting the suspension of wet clothes, in order to dry, about different parts of the apartment, and even by carelessness respecting the washing of the floor. The process of drying is the process of producing cold, and that too of the most noxious kind; for cold, when combined with moisture, has been proved, in an excessive degree, inimical to the animal economy. Damp is equally insidious and detrimental. We are fully persuaded that from this cause originate many scrophulous and other infantile ailments; and that where the diseases have been fancifully attributed to deleterious impregnations in the waters we drink, and various other sources. By every individual, but more especially by the parents and guardians of infancy and youth, freedom from damp should be the first and great requisite in the choice of apartments and houses.

But to return to the infant's dress. The covering which we have recommended ought to be continued for the first six or seven weeks of infancy; during this period, as we have already observed, nourishment, warmth, and repose, are almost its only requisites. After this time, however, or towards the close of the second month, the infant economy begins to change; vascular action comes now to be connected with voluntary muscular motion; the percipient faculty is gradually developed; and the whole organization appears to undergo a change. The body is now warmed in a greater degree and more regular manner, by actions of its own production, and heat of its own formation. Exterior warmth is daily less necessary; and that quantity and kind of clothing, which before were proper and genial, now become irksome and

debilitating. If with this progress of growth the summer months are at the same time about to appear, the covering of the child may, in a short time, be reduced even to a shirt and single external garment: the utility of this light clothing will be rendered evident by the feelings and expressions of the infant. It is almost unnecessary to observe, that general precepts are incapable of undeviating and indiscriminate application. The changes of the weather, the season of the year, and the delicacy or robustness of the constitution, will interfere with every rule, and give exercise to the independant judgment of every parent. Providence, however, has so ordained it, that in this, as in every other respect, the dictates of nature, which are communicated by the desire and aversion of the infant, furnish the most faithful directories with respect to its management; and these are conveyed with such distinctness and precision as to be generally intelligible. It is only by disobeying nature's laws that, in the treatment of infancy, we have wandered wide of the path of rectitude, and are under the necessity of retracing our steps.

We now close the present section by a few additional remarks on the much-contested question of bathing. It has already been observed, that an infant, upon its first entrance into the world, should be immediately washed with tepid or warm water. Others recommend immersion rather than ablution. " For a new-born infant (says Dr. Beddoes) I should prefer instant immersion in water at eighty degrees to washing." It is perhaps immaterial to which mode of cleansing we have recourse, unless the latter may be deemed objectionable on account of the unnecessary shock it may occasion to the tender frame. It is likewise to be observed, that conveniences for the former are procured with more facility than the latter; and that it is not every nursery that can, without difficulty, be furnished with a " proper vessel for a warm bath." The question, however, now to be resolved is, in what mode, and at what temperature, bathing or washing should be continued through the period of childhood. This question, like others, is incapable of decision by an appeal to separate principles. By one writer, daily immersion in, or ablution with, cold water, for the first two or three years of life, is earnestly recommended; by another, it is condemned as an unnecessary piece of cruelty, while tepid washing is directed to supply its place. Like the different decisions past on the cameleon's hue, these precepts, although opposite, may each be equally just. The weakly infant shall be washed " with cold water into irrecoverable debility," into convulsions and death; while to the robust and hardy child the same element at the same temperature shall be congenial, and by its use he will be prepared for the variations of cold and heat, to which he will in the course of life be exposed. In a popular treatise on consumption, recently published by Dr. Reid, we meet with the following judicious regulations on the subject of bathing: " It may be proper to premise (says our author), that by the cold bath is understood water at an inferior standard to eighty degrees of Fahrenheit's thermometer. Between this point and that of 90 degrees the bath may be termed temperate; and it is only beyond this last degree of heat that the epithet warm can with propriety be applied. From neglecting accurately to observe these distinctions, which are of very material importance, a want of precision has often connected itself with directions for the employment of both warm and cold bathing.

" Immersion in cold water, during the period of infancy, has been very generally recommended, and too often had recourse to, in an indiscriminate manner, to preserve health, and ensure hardiness. The author has remarked several instances where sensible, and sometimes considerable, injury has arisen from neglecting to observe the precautions necessary to regulate the employment of this important agent in very early years. In infancy danger to the lungs from cold bathing has been stated to exist in a very inferior degree; and by the practice of dipping children in cold water, susceptibility to the injurious impression of cold, in succeeding years, has been thought to be materially diminished. This principle, in the abstract, is undoubtely correct; and, with the exceptions and precautions now to be mentioned, may be pursued with propriety and advantage. Two infants may be supposed of one family of reverse constitutions. In the one a general torpor, debility, and great susceptibility to the impression of cold, shall prevail: in the other comparative vigour, activity, and warmth. That degree of cold which would refresh and invigorate the one, would confirm, debility and augment torpor in the other. A bath which is not cold to the sensations must, in the first instance at least, be resorted to for the weaker infant; and in neither case should immersion in cold water be practised when the external warmth of the body is inferior in degree to its general standard; when after immersion the body appears to be chilled, or when returning heat is attended with febrile languor, instead of the grateful and genial warmth characteristic of the appropriate action of exciting powers. If the practice of immersion is guided by a cautious observance of these particulars, it may be adopted with safety, and will be attended with success; but a total neglect of bathing would be greatly preferable to the severe and incautious manner in which infants are frequently exposed to these violent and rapid changes in the temperature." It ought to be added, that whether washing or immersion is employed, much care should be taken in drying the skin, particularly in those parts in which it is loosely situated, as about the groin, and in the arm-pits.

It may be necessary likewise to observe, that the breast ought on no account to be given to the child while being washed and dressed. A perseverance in this respect will ultimately prove of essential advantage. The habits of the child are greatly under the command of the parent or nurse. At the expense of a few temporary tears permanent comfort may be attained.

Sect. III.—*Air and exercise.*

It has recently been conjectured that the air we breathe contributes equally, and nearly in the same manner, to the nourishment of the body, with the aliment that is taken into the stomach: respecting the grounds of this opinion it would not be in place, in the present article, to institute any inquiry. (See Physiology; and Materia Medica, section Dietetics). We have here only to impress the necessity of a constant and unremitting regard to ventilation, in order to ensure a healthful condition in the infantile economy.

Both the truth and importance of this principle would seem too obvious even to require notice by a writer on regimen, had he not daily opportunities of witnessing the mischief arising from neglecting its application. The public mind, however, appears to be at length awakening from a long lethargy of prejudice and error. We at length begin to breath and to live. Even among the poorer and least informed classes of society, cleanliness and ventilation come to be acknowledged as the surest barriers against the invasion of disease. Although, however, on this subject modern science has much to boast, much likewise remains to be accomplished; and even in the present day examples cannot be too frequently pressed upon public observation of the injurious tendency, especially in the susceptible and delicate period of infancy, of neglected ventilation. "There is reason to suppose that, from the inattention of our ancestors to fresh air, multitudes must have perished in the very dawn of existence. In our times grown persons have been dangerously affected by such a deficiency of this necessary of life, as did not even produce immediate uneasiness. *Infants have perished in great numbers by a slow suffocation, terminating in convulsions.* As soon as the want of ventilation was observed the mortality has ceased." Beddoes. A fact, of which the following relation furnishes irrefragable evidence. In the lying in hospital at Dublin 2,944 infants, out of 7,650, died in the year 1782, within the first fortnight from their birth: they almost all expired in convulsions; many foamed at the mouth, their thumbs were drawn into the palms of their hands, their jaws were locked, their faces swelled, and they presented, in a greater or inferior degree, every appearance of suffocation. This last circumstance at length induced an inquiry whether the rooms were not too close, and insufficiently ventilated. The apartments of the hospital were rendered more airy; and the consequence has been, that the proportion of deaths, according to the register of the succeeding years, is diminished from three to one.

Such facts as these cannot be too often made to pass under review. By the parent anxious for the well-being of her offspring they ought constantly to be enforced upon the minds of servants and nurses, whose supineness in respect to proper ventilation is often only to be equalled by their mismanagement in other particulars. This indolence is often by servants carried to such an extent as very materially to injure their own health. "In a large family (says Dr. Darwin) many female servants slept in one room, which they had contrived to render inaccessible to every blast of air. I saw four who were thus seized with convulsions. They were removed into more airy apartments, but were some weeks before they all regained their health." Had infants unfortunately been confined in the same tainted atmosphere, convulsions in these would have been more readily induced, and might perhaps have proved fatal! A child then ought never, if it can be avoided, to be permitted to sleep with many individuals in the same apartment. It should not be lulled to rest in its nurse's arms. When put to sleep in the couch or cradle the face must not be covered; at night the clothes should be entirely changed; after the first or second month it should be daily taken out in the open air, when the weather is not cold or damp: this is best done in the forenoon, immediately upon being washed and dressed; care being taken that the infant is not carried too much in one position, and that it does not suffer from cold. Every impediment to the purity of the air within doors is to be as speedily as possible removed; and when the skin is preternaturally hot, or the little patient becomes restless and febrile, the fires of the nursery are to be extinguished, the windows thrown open, or the apartments changed.

To the full enjoyment of the atmosphere the free use of the limbs must likewise be added. On exercise scarcely any thing remains to be said. Freedom from all constraint is implied in the mode of dress above recommended. To those, however, who imagine that nature can be assisted by the contrivances of art, or that symmetry of form is to be insured by unnatural restriction, it may not be improper to observe, that deformities are only known in those countries where mechanical dexterity has been called upon to prevent them. "The infants of the Caffres (says the author of Travels into the interior of Southern Africa), soon after birth, are suffered to crawl about perfectly naked; and at six or seven months they are able to run. A cripple or deformed person is never seen. In Egypt, again, the haram is the cradle or school of infancy. The new-born feeble being is not there swaddled and fillited up in a swathe, the source of a thousand diseases. Laid naked on a mat, exposed in a vast chamber to the pure air, he breathes freely, and with his delicate limbs sprawls at pleasure. The new element in which he is to live is not entered with pain and tears. Daily bathed beneath his mother's eye he grows apace. Free to act he tries his coming powers; rolls, crawls, rises, and should he fall, cannot much hurt himself on the carpet or mat that covers the floor."

PART II.

DISEASES OF INFANCY.

SEC. I.—*Mesenteric atrophy* (Tabes mesenterica, Atrophia infantilis).

This is, in a great measure, the origin and root of the major part of infantile diseases. An affection of the mesenteric glands in children is often connected with, is not unusually the occasion of, and is still more frequently mistaken for, worms; it is the medium through which rickets are produced; it is, in general, the more immediate cause of diarrhœas, and other bowel complaints; and in several instances has been the "forerunner, if not the cause, of hydrocephalus, or dropsy in the brain."

Than this no complaint bears more evident characters. The physician who has been accustomed to the general aspect of infantile disorders, will most commonly commence his inquiries by an inspection of the abdomen. If he perceives a fulness and tenseness about the navel, and a general protuberance and hardness about the belly, attended sometimes with a knotty irregularity, indicating glandular tumefaction; and if, combined with this symptom, a tendency to atrophy, or, as it is called, falling away in flesh and strength, is observed; a greater or inferior degree of mesenteric consumption is present. Such then are the never-failing attendants of the disorder now under notice; they are its distinct and prominent features. A variety, however, of other adjunctive symptoms, for the most part, display themselves, and constitute part of the malady. Sometimes an universal languor and

listlessness will be connected with aversion to food; at others an inordinate appetite is present. The bowels are at times costive, but at others the contrary; the evacuations are discoloured, and unhealthy in their appearance; they are, for the most part, slimy, or viscid in their consistence, but are discharged, both with respect to quantity and quality, with the utmost irregularity: the countenance is pale, "except when the hectic flush prints its deceitful and ill-omened animation on the cheek:" the features are, for the most part, full and tumid: the eye is dull: the breathing is oppressed, and spasmodic: the pulse is invariably feeble, but is sometimes slow, and at others inordinately accelerated. In the advanced stages swellings of the feet and ancles are sometimes observed. The little sufferer generally moans piteously; and this, if the disorder has arrived to any considerable extent, is almost the only sign which is given of consciousness or feeling.

Causes.—Mesenteric atrophy is most prevalent among the children of the poor, especially in large cities, and in dirty confined situations. "The noxious powers producing it," in the language of Dr. Brown, (see BRUNONIAN SYSTEM.) "are the same with those of every other asthenia. They are want of food, or diet of watery matter and bread; cold and moisture, the latter increasing the effects of the former; too little nursing (gestationis justo minus); habitual vomiting and purging; irregularities in the times of sleep, meals, and every other part of infantile management; filth; impure air; an inattention to the instincts of nature in the treatment of children." Elementa Medicinæ. To these causes Dr. Brown ought to have added the practice of giving children fermented or spirituous liquors, and those other artificial stimuli, to which we have referred in the former part of the present essay. This custom is extremely prevalent in the inferior classes of society; and hence, in part, the frequency of mesenteric atrophy among the offspring of the poor.

Immediate cause of, and constitutions most obnoxious to, mesenteric consumptions.—The unusual bulk of the abdomen, which is so characteristic of this disease, obviously depends upon a deranged state of the mesenteric glands. The tumefaction, however, does not arise from the source to which it is vulgarly referred, "the presence of tough, ropy humours, causing an obstruction in the tumefied parts." The theory of mechanical obstruction is indeed totally founded in error. It is inconsistent with the laws of the animal economy. It is incompatible with living action; and, as we shall immediately have occasion to observe, has been the cause of much and serious mischief, both in the domestic, and even the professional treatment, of this and other ailments. "The idea of attenuating humours, purifying blood, and clearing passages, rests upon a wrong principle." So far indeed from the glands of the mesentery being less permeable under disease than when in a state of health, the exact contrary is the fact; and not only is their area enlarged, but new vessels are often at the same time formed; and hence the morbid increase of bulk.

The attendant atrophy is easy of explanation. The deranged action of the glands in question interferes with the due preparation of the chyle, the whole of which has to undergo a preparation in these organs. The chyle is the fluid from which the blood is formed: on the quantity and quality of the blood depend health, growth, and life; by its deficiency, or want of due proportion in its component principles, debility, disease, and atrophy, are produced.

The attendant symptoms are not difficult to account for; the torpid and irregular state of the bowels is partly owing to the general inactivity in the lymphatics of the liver; hence the thinner portions of the bile remain unabsorbed, and this fluid is in consequence too diluted to afford a due excitation to the intestinal fibre. The sliminess and viscidity of the fæces arise from the disordered state of the glands of the intestines; and the œdematous swellings of the feet are evidences of a general inactivity, or deficient excitement, pervading the whole lymphatic system.

The constitutions in which tabes mesenterica most readily makes its appearance, are those which are denominated scrophulous. The marks of scrophula we shall not here enumerate; it may be sufficient to observe, that in habits of this description the lymphatic and glandular systems are especially prone to suffer from the exciting causes of disease. This indeed is more or less the case in every individual during growth, as, at this period of existence, the office which these vessels perform in the animal economy, is more important and complicated than in the succeeding stages of life.

Treatment.—The most effectual remedies are necessarily the converse of those which occasioned the disease. These we shall likewise enumerate from the Elements of Dr. Brown: "nourishing exciting milk; three or four meals in the course of the day, composed chiefly of warm milk; pure animal, and by no means weak, soups, mixed with wheaten flour or bread; a due temperature, so that a genial warmth may be preserved, without producing irritation, or occasioning too copious sweat; avoiding every species of evacuation; good nursing; a proper regulation of the times of sleep, food, and every other circumstance connected with the management of the susceptible and tender condition of infancy; cleanliness; tepid bathing in moderately cold weather, and cold bathing in warm; pure air; being sent out of doors as much as possible, excepting when the weather is damp; and, finally, a judicious attention to desires and propensities; this ought to be carried to such an extent as to obviate, if possible, the most trifling local irritation, as by the scratching of a part that itches.

The above are necessarily adapted to the milder forms of the complaint. When the disorder has arrived to a certain extent, medicinal is now required in aid of domestic treatment: for although the mesenteric atrophy, unless it is a consequence of defective structure, may at all times be prevented, and in its earlier stages with facility combated, without the aid of drugs; these, at length, come to be absolutely indispensable. It ought, however, to be impressed on the public mind, that pharmacy, although it may correct the errors, can in no wise become a substitute for, or supply the deficiencies of, regimen.

The objects of the medical practitioner, in the treatment of the disease in question, will be twofold. 1st. That of immediately and forcibly stimulating the lacteals and mesenteric glands; and, 2dly, the preservation

of a due and equable excitement in order to obviate the recurrence of the disorder.

[N. B. For the explanation of any terms that may not be familiar, the reader is referred to the articles ANATOMY, PHYSIOLOGY, and MEDICINE.]

The first of the above intentions is most speedily and effectually accomplished by mercurial purgatives: and of these calomel (submurias hydrargyri) is generally to be preferred. The benefit which has often resulted from preparations of mercury, particularly in the form of calomel, has frequently been accounted for upon very erroneous principles. It is customary to attribute every complaint of childhood, where the stomach and intestines show marks of derangement, to worms. With the signs of the actual existence of the animalculæ, we have already remarked those of tabes mesenterica are, from their affinity, often confounded. Advertisements of infallible cures for worms, as indeed for every other malady, are constantly before the public: these, for the most part, contain mercury, as the only agent of consequence in their composition; and from the operation of this medicine upon the diseased glands, provided, by accident, the quantity taken is proportioned to the age and constitution of the recipient, immediate, and temporary relief is perceptible. Worms are supposed to be expelled the system, and the infallible medicine is indiscriminately, and often fatally, circulated among the public.

A further error with respect to the agency of calomel in the mesenteric affections, is that of attributing its effects solely to its purgative quality. This last error is not confined to the unprofessional. Ill-founded notions, as we have above hinted, are still too general in regard to obstructing humours; and the cure of this disorder, with all others which are conjectured to arise from obstruction, is consequently imagined to be performed by evacuating medicines. We are disposed to believe that a recent publication, although in the main extremely useful, has, by the unqualified recommendation of purgatives, given too much encouragement to this mistaken principle.

Dr. Hamilton, the author of the work to which we allude, has classed, under the title of marasmus, the asthenic affections which are common to young persons, and of which the disorder now under consideration is one of the most general; and these affections he "is convinced have often been removed by the diligent exhibition of purgative medicines." Now we are fully persuaded, although actual, and even repeated, purgations are in many cases indispensable; that for the most part, especially in "incipient marasmus," such a qualification in the dose of cathartics is to be preferred as may ensure an excitation of the glandular, lacteal, and lymphatic organs (the organs principally concerned in the production of the complaints in question), without copiously evacuating the contents of the bowels. For this persuasion we have the authority of experience. Further, it is to be remarked, even where large and repeated evacuations, in these diseases of debility especially, have been followed by beneficial effects, that, even then, the evacuation itself has constituted but a share in the process of recovery. This principle may be evidenced in the example of either vomiting or purging. Let a case be supposed of mesenteric affection carried to such an extent, that the torpid condition of the lacteal glands has extended itself to the hepatic and biliary organs; where even dropsical effusions have taken place, and contributed to the enlargement of the belly; and where this abdominal protuberance is contrasted, in a most distressing degree, with the emaciation of the limbs. Under these circumstances (and the writer of the present article has witnessed them in the full extent described), if either a quantity of ipecacuana, emetic tartar, or any other emetic drug, is given sufficient to occasion vomiting, or such a dose of calomel as alone, or in combination, may produce a copious alvine discharge: the immediate result will prove, that the principal part of the medicinal agency has been constituted by a sudden and powerful impulse communicated to the glandular and absorbent vessels. The liver shall commence a regular secretion of bile, the fæces in consequence assume a proper colour and consistence, the skin shall lose suddenly its sallow sickly hue, the size of the abdomen be lessened, and even the swellings of the ancles be diminished; all evincing, in the most unequivocal manner, an increased action in the absorbent system.

By those who are aware of the importance of acquiring correct notions in respect to medicinal agency, the above remarks, although perhaps in some measure irregularly introduced, will not be deemed misplaced. They will, it is hoped, facilitate the conception, and serve to curtail the discussion, of the remaining disorders that are to be treated of in this article.

We now recur to the more immediate subject of the present section.

We have observed, that the first object of the physician, in cases of deeply rooted mesenteric disorder, is to produce an immediate and forcible excitement in the lacteal glands; the manner in which this object is to be attained may be gathered from the preceding remarks. Either calomel purgatives, or emetic substances, are to be employed, according to the circumstances of the case, or the inclination of the practitioner; and now the judicious regulations of diet and regimen prescribed by Brown, are to be assisted by medicines, in order to accomplish the second purpose, that of preserving a due excitement to secure against the recurrence of the disease.

The physician will be careful to keep in view, that the absorbent system is principally concerned in this, as well as in the other asthenia of infants. It is to this part of the frame that remedies are especially to be directed. Among the various stimuli, those therefore are to be preferred, the influence of which appears in an especial manner to be directed to this part of the organization. Chalybeates have this property in a remarkable degree; and accordingly one or other of the various preparations of steel has been judiciously and successfully had recourse to in tabes mesenterica: these are to be conjoined with pure air, and due exercise, without which the most appropriate medicines will be in vain administered. The continued use of small doses of calomel, or other mercurial preparations, either in conjunction with, and sometimes to the exclusion of, steel, will prove highly useful in restoring a due energy and action to the absorbents. These, like all other active medicinals, require much address and discrimination in

their employment. It is from the presence of mercury, as above hinted, that both the utility and dangerous tendency of quack medicines are for the most part derived.

In the practice of the writer of this article, extremely small, and very gradually augmented, doses of digitalis have appeared to restore, in a remarkable degree, the wonted vigour of the lacteal vessels. The free use of this very important and active medicine has long been admitted in dropsy, an affection generally attended with great debility. In tabes mesenterica we believe its employment is novel; but we are, at the same time, persuaded, from the result of several cases of this and other modifications of infantile asthenia, that foxglove might be made, under due regulation, a very successful agent in the treatment of these complaints. Under these circumstances, on account of the comparative minuteness of the dose, the digitalis is best given in the form of tincture; a preparation which has not hitherto been received into the London Pharmacopeia. See Materia Medica, and Pharmacy.

Sect. II.—*Water in the head.* (Hydrocephalus.)

The discriminating characters of this disease demand assiduous attention from the medical practitioner. It cannot be doubted that a great number of children are constantly destroyed by water in the brain, where the nature of the malady has been entirely misunderstood, and the symptoms referred to other sources, most commonly worms; while, on the other hand, hydrocephalus has been very frequently suspected, and the event has proved that the suspicion was destitute of any proper foundation.

Hydrocephalus is generally divided by authors into the internal, or that in which the fluid is contained in the ventricles of the brain; and external, where the disease is exterior to the substance of this organ, and the water is found in its investing membranes. The first species has likewise been denominated acute, the second chronic. This division, however, is calculated to mislead; not merely on account of the frequent connection between the two species (internal and external) of hydrocephalus, but because the former, as well as the latter, is oftentimes chronic, and by no means necessarily preceded by an inflammatory affection of the parts concerned in its production.

The chronic internal, chronic external, and the acute, species of hydrocephalus, would constitute a classification of the disease, approaching nearer to accuracy than that which has been hitherto adopted; and we shall proceed to give a brief description of each, requesting the reader to recollect that the different kinds are often mixed, and consequently exhibit characters in an almost endless variety.

Chronic internal.—This, although overlooked in the ordinary division, is perhaps the most usual form in which the affection presents itself; it arises from the same disposition in the habit, and is oftentimes combined with the disease treated of in the preceding section. More commonly, however, it is in a manner vicarious of this last; and the same causes may, perhaps from accidental circumstances, at one time occasion tabes mesenterica, which would at another have produced hydrocephalus. Its symptoms are less decided than those of the other species. When, however, in children of a sluggish habit, or scrophulous constitution, an unusual drowsiness or stupor is present, the child gradually loses his vivacity and spirits, is indisposed to make any exertion of his limbs, is unusually fretful and peevish, complains or exhibits signs of an uneasiness in the head, is affected with convulsive fits without any apparent cause, has an unusually tardy pulse, and more especially if the pupil of the eye is not found to contract upon the application of light, there is reason to suspect the presence of water in the brain, although there may be no symptoms of external disease, and no preternatural enlargement of the head, except what is usually met with in young persons of a torpid scrophulous habit; and the suspicion has been too often confirmed by dissection, even where a fatal termination has happened, without being preceded, during any period of the malady, by the symptoms immediately to be mentioned, characteristic of the acute species. This first kind of hydrocephalus is succinctly described by Dr. Heberden, in the following words: "Capitis dolores, manus ad caput crebro admotæ, clamores subiti, distensio nervorum, stupor, mentis perturbatio, motus venarum lentus, postremo cæcitas." He adds, "Justam hujus morbi suspicionem injiciunt hæc symptomata etiamsi capitis moles non fuerit aucta."

Chronic external.—The head of an infant at, or soon after, the period of birth exhibits a preternatural size and form; the regular process of ossification does not take place; but the principal part of the external surface of the cranium continues soft and yielding, while not unfrequently, in the progress of the complaint, an undulation of a fluid may be perceived by applying the hand to the sutures of the skull. As the disease continues to advance, the signs of its existence become shortly obvious to the most superficial observation; not only does the head increase to an enormous size, but the growth of other parts is in a proportionate ratio defective; the limbs do not often acquire a much greater bulk than at birth; at the ordinary period of teething no teeth present themselves; the percipient faculty is not gradually unfolded, as in other infants; and, indeed, although vitality is preserved, it appears to be a vitality almost entirely unconnected with feeling. In this state of torpid existence life however is, in some instances, prolonged for four, six, or even a greater number of years. In the Commentaries of Van Sweiten, we have the relation of life being maintained under this malady for thirty years: this, however, is an anomaly; and indeed the hydrocephalic patient seldom survives the second year.

Acute hydrocephalus.—The acute, phrenitic, inflammatory, or, as it has been termed by some writers, apoplectic hydrocephalus, is not, like the other species, entirely confined to any constitution. Although most frequent in children under twelve years, it is sometimes observed in adults. It has been divided by Dr. Whytt, and others who have followed him, into three distinct stages: the first of which is invariably characterised by a pulse of much celerity and comparative strength; in the second the pulsations become slower, and more feeble; in the third and last period their rapidity is increased even beyond that of the primary stage; but this increased action is now connected with extreme debility. These different changes in the circulation are not, however, always

to be traced even in the acute species of hydrocephalus, in that order which the observations of Dr. Whytt would lead us to suppose.

Obscure affections of the stomach, a general feeling of lassitude, with sometimes a kind of palsy of the limbs, or an affection of them, in some measure similar to that observed in St. Vitus's dance, if the child has previously been able to walk, sometimes present themselves as precursors of the first, or the inflammatory stage; at other times the feverish state, intolerance of light, violent pains in the head, and vomiting, are the first signs of disorder that are noticed. These symptoms are in some cases connected, according to the observations of Dr. Rush, with an impatience of sound; the pain of the head is often confined to one side; and in proportion to its intensity the nausea and vomiting becomes less urgent, while with the remission of the pain these affections of the stomach are disposed to recur. Respiration at this time is spasmodic and irregular; the bowels are generally so costive as to require very drastic purgatives, in order to produce evacuations. This state of the complaint continues sometimes for several days, but is more usually in a shorter period succeeded by the second, which commences by a sudden reduction of the pulse, and other symptoms of irritation. The pain of the head now becomes less urgent, torpor succeeds to watchfulness, the infant lifts his hands to his head, and frequently utters piercing screams (clamores subiti); a degree of strabismus takes place of the previously morbid susceptibility of light; the little patient lies in an horizontal posture, with the head low, and shows an indisposition to be taken up; the bowels still continue torpid; the urine not unfrequently deposits a thick sediment; and after these symptoms have lasted from seven to fourteen days, the complaint sometimes appears suddenly to decline. This semblance of returning health is, however, deceitful, and is but a prelude to the final period of the complaint: it is now that the pulse increases in frequency, and oftentimes so quick as not to be counted. Dr. Whytt informs us that in some children he has been able to number 210 pulsations in the space of a minute; this extraordinary rapidity, however, does not last through the whole of the day; it comes on and declines with the accessions and remissions of the hectic flush in the cheek. The eyes at length become insensible to the strongest light, convulsions come on, and life is terminated. The duration of this last period, like that of the others, is irregular. Sometimes the patient is carried off in less than a week from its commencement; at other times the child lingers in a hectic state for three, four, or six weeks; and Dr. Monro has informed us, that the last state has been known to be protracted even to the fourth month.

Causes.—The two first species of the complaint are decidedly of a scrophulous nature. They generally come on without any evident exciting cause, and, like other asthenic affections, in the early periods of life, originate from lymphatic debility, without previous excitement in the vessels of the brain to produce the effusion: the last species is perhaps always preceded by an inflammation in the internal vessels of the brain. The immediate cause of this irritation is not, however, in every instance to be detected; it may arise in subjects predisposed, in common with all other inflammations, from the sudden alternations of cold and heat. It has been observed to supervene upon the contagious eruptive affections, especially when these have been unusually violent; and Dr. Beddoes, in a letter to Dr. Darwin, inquires "whether it may not happen more frequently than has been suspected from external injury?" Zoonomia.

Treatment.—Evacuations of every kind, viz. cathartics, sudorifics, emetics, general and local blood-letting, as well as the external application of cold, and of blisters to the scalp, with due attention to the erect position of the head, had all, in conjunction or separately, been tried in the acute species of hydrocephalus, but, according to the general report of physicians, without effect. It is in what Dr. Whytt has called the first state of hydrocephalus that the above treatment should be vigorously put in practice, and it is only in this stage that we can look with confidence for a successful issue from any treatment. When a collection of water has actually taken place within the ventricles of the brain, the disease has almost invariably ended in death.

In consequence, therefore, of the ill success that had attended the common routine of treatment in hydrocephalus, Dr. Dobson, of Liverpool, was induced to make trial of mercurials, with an intention of exciting the absorbents of the brain, and in this manner removing the extravasated fluid. The event appeared to justify his theory; and we have several cases recorded by this physician and by others, in which mercury, carried to the extent of salivation, accomplished a speedy and effectual cure. The following case is from Dr. Percival: "One of my own children, a girl, aged three years and three months, has lately been a severe sufferer under this alarming malady. As soon as the characteristic symptoms of the disease clearly manifested themselves, I laid aside all other remedies, convinced by repeated observation of their insufficiency, and trusted solely, though with much solicitude, to the internal and external use of mercury. In forty-eight hours, signs of amendment appeared, and her recovery was perfected in six days. During this space of time, thirteen grains of calomel were administered, and seven scruples of unguentum mercuriale fortius carefully rubbed into the legs."

With the same design of exciting the absorbents, digitalis has recently been employed. "In one child," says Dr. Darwin, "I tried the foxglove in tincture, but it was given with too timid a hand and too late in the disease to determine its effects." In the work of Dr. Reid, to which we referred in a former part of this article, we meet with the following observations: "The universality of lymphatic absorbents is rather conceived than actually demonstrated. Dissection has hitherto not been able to detect these vessels in the brain; analogy, however, favours the supposition of their existence. If that frequent and too fatal disease of young persons, water in the brain, admits of cure, the remedies which effect it, must necessarily operate by producing an absorption of the effused fluid. The author imagines he has witnessed the cure of hydrocephalus by means of foxglove. The symptoms, however, of worms and other infantile affections, so oftem resemble those indicative of water in the ventricles of the brain, that it is scarcely possible to decide with absolute certainty on the interesting question of the

inevitable fatality or remediable nature of hydrocephalus."

If foxglove should be proved by future experience to succeed as a remedy for this alarming malady, its modus operandi must be referred to the extraordinary faculty which it possesses of repressing the arterial, while it stimulates the absorbent system. Both in the acute and chronic hydrocephalus, it appears to be deserving of a more extensive trial. To the earlier stages of the former we should, *a priori*, be disposed to conceive it more applicable than even mercury.

Sect. III.—*Worms.* (Vermes.)

The marks by which the presence of worms is indicated are confessedly at times, both in the infant and adult, obscure and equivocal. In the majority of cases, however, the phenomena which they present require only for their detection a careful and discerning scrutiny.

In persons affected with worms, the countenance in general has a peculiar livid and dirty kind of appearance, very different from that which characterizes mere lymphatic debility, as in tabes mesenterica, and hydrocephalus. The eyes become dull, the pupil dilated, but not averse to light, as in hydrocephalus, the upper lip swelled, the sides of the nostrils enlarged, and there is almost constantly a violent itching of their internal membrane. The breath is remarkably offensive, saliva is secreted in unusual abundance; during sleep there is most generally some grinding of the teeth, and epileptic affections are by no means uncommon; the pulse is intermittent, the febrile irritation is not always of the hectic kind, the appetite is often voracious, lancinating pains are complained of in the stomach and bowels, and tenesmus, attended with a distressing irritation about the anus, is, especially from some species of worms, exceedingly frequent. Cough is not uncommon. These last, however, are more frequent symptoms in the adult than in the child. See Medicine.

Causes.—"The tumid belly, bloated countenance, and swelled upper lip," says Dr. Darwin, "are concommitant circumstances attending the general inactivity of the absorbent system, which is therefore to be esteemed the remote cause of the generation of worms." Worms, however, are often produced through the medium of intestinal vicidities, independantly of the absorbent vessels. The immediately exciting causes are some of those already mentioned as productive of mesenteric atrophy, more especially the reception into the stomach of indigestible substances. Dr. Darwin, indeed, supposes, that not merely the nidus of worms is thus formed from aliment incapable of assimilation, but that these animalculæ are actually received from without: for this opinion, however, there does not appear any foundation. Worms are actually engendered in the alimentary passage.

Treatment.—Emetics; mercurial purgatives, chalybeates; vegetable bitters; avoiding indigestible aliment. For an account of the different kinds of worms, and specific anthelmintics, consult the articles Medicine and Materia Medica.

Sect. IV.—*Rickets.* (Rachites. Atrophia infantilis.)

This is likewise an affection of the lymphatic system. Every one knows the characters by which it is marked. An infant with a large head, protuberant forehead, swellings in the smaller joints, depressed flattened ribs, emaciated limbs, and tumid abdomen, is decidedly rickety. These symptoms, in common with the other astheniæ of infants, usually make their appearance before the second year. The first indication of a rickety tendency is a remarkable flaccidity of the muscular fibre; disinclination to exertion follows; and the irregularities above enumerated shortly supervene, followed by hectic, cough, confirmed atrophy, death, or permanently distorted limbs.

Causes.—Debility, most commonly of an hereditary nature, constitutes the predisposition to rickets. Bad air, bad nursing, improper diet, uncleanliness, and damp, are its exciting causes. Hoffman describes the proximate cause to be a deficient supply of nervous influence to the spinal marrow, preventing the due nutrition of parts. Dr. Cullen supposes, a deficiency of bony matter in the fluids constitutes the disease. A more correct account, however, of the essentials of rickets, would make it to consist in deficient excitement or power in those vessels, by the action of which osseous matter is thrown out, and bone constituted.

Treatment.—Indication 1st. To cleanse the first passages from obstructions. Methodus medendi: emetics, cathartics, calomel.

Indication 2d. To restore due energy to the secretory vessels of the bones. M. M. chalybeates, exercise, bathing.

Sect. V.—*Disorder in the bowels.* (Diarrhœa infantilis.)

Among the morbi infantiles in the yearly catalogue of every medical practitioner, diarrhœa occupies a conspicuous situation. The griping, green and otherwise discoloured fæces, pains in the abdomen, with drawing up of the knees towards the stomach, severe crying, febrile irritation, and a greater or less degree of actual convulsions, are perhaps the most common among the diseases of infancy.

Causes.—These affections, as we have already observed, are almost invariably occasioned by improper diet. Dr. Darwin gives us the following relation: "A child of a week old, which had been taken from the breast of its dying mother, and had by some uncommon error been suffered to take no food but water-gruel, became sick and griped in 24 hours, was convulsed on the second day, and died on the third!" He adds, "That among the poor children of Derby who are thus fed hundreds are starved into scrophula, and either perish or live in a state of wretched debility." Zoonomia.

Treatment.—Calomel, with rhubard, is to be immediately given, which is to be followed by antacids, such as prepared chalk and magnesia. With these are to be connected, according to the violence of the disorder, aromatics and stimulants, such as cinnamon, nutmeg, and opium. Sometimes it is necessary to give an emetic. In all cases indigestible food is to be avoided.

Sect. VI.—*Affections occasioned by teething.* (Dentitio.)

Pains in the head, convulsions, frequent and sudden startings, more especially in sleep, eruptions on the skin, disorders of the stomach and bowels, cough, and hectic fever, are not unfrequently occasioned by the process of toothing. Dr. Darwin conjectures, that "the pain of toothing often begins much earlier than is suspected;"

and that the apparent cause of the disease is in reality its cure, as the convulsions, which are oftentimes the most violent and then by far the most alarming of the above symptoms, are commonly relieved when "the gum swells and becomes inflammed; at other times a diarrhœa supervenes, which is generally esteemed a favourable circumstance."

In difficult dentition, the pains in the head, convulsions, vomiting, and hectic, sometimes give rise to the suspicion of hydrocephalus: from this, however, the disease in question may generally be distinguished with facility by the ease with which, in the last case, the bowels are evacuated; by the inflammatory redness of the gum, and by the pupil of the eye being dilated in an obscure, and contracted in a vivid light, the contrary of which takes place in hydrocephalus.

Treatment.—Frequent doses of rhubarb, with magnesia, will often allay the intestinal irritation, and mitigate the teething cough. The gums are to be lanced in all cases where the redness and swelling are considerable. This practice can indeed never be objectionable. Antispasmodics for the convulsions are inefficacious while the cause remains.

Sect. VII.—*Croup.* (Cynanche trachealis.)

The characteristics, or pathognomic symptoms of this disease are, difficult respiration, loud and stridulous cough, with the emission of a sound of a peculiar nature, which has been compared to the crow of a young cock.

These symptoms sometimes supervene, upon the common precursors of violent inflammation; at other times the disease is formed without previous warning, and has been known to prove fatal in a very few hours from its apparent commencement. If life is not speedily terminated in this manner, the disorder frequently runs on for the space of six days, and terminates for the most part by crisis, with the evacuation of much pale urine.

Causes.—The croup is an inflammation of the upper part, as the peripeneumony is of the lower part of the same organ, viz. the trachea or windpipe. It originates from the same sources as other inflammation. The circumstance of its frequent occurrence and fatal tendency in infants, appears to be owing to the extremely disproportionate smallness of the glottis at this period of life. The cause of death, when it happens suddenly, is a deposition of concreted mucus (consequent upon the inflammation), which lines the trachea, and fills up the bronchial cavities. Independantly, however, of this circumstance, sudden death may be occasioned by the great loss of power in the muscular fibres of the glottis, induced by the previously high excitement. "infantes enim miram incitationis vicissitucinem, brevissimis temporum spatiis, experiuntur."

Treatment.—This, to be effectual, must be speedy and decisive. Emetics; copious bleeding from the arm, and leeches applied near to the part affected; blisters; warm bath; antimonials. Recently, calomel in large doses has been tried, and with success. Might not digitalis prove useful in consequence of its extraordinary power in rapidly reducing arterial excitement?

N. B. Croup, in some instances, assumes more of the asthenic than of the inflammatory nature; and in this case the disorder of the glottis is often protracted to a longer period. The treatment in this latter species requires to be stimulating. Calomel; opiates; blisters; volatile embrocations to the throat; nourishing diet.

For those diseases of young persons which often require local, in connection with general treatment, such as distortions of the spine, affections of the eyes, scrophulous swellings of lymphatic glands, &c. consult the article Surgery.

For eruptive and contagious diseases, see Medicine.

INFANT. From the observations daily made on the actions of infants, as to their arriving at discretion, the laws and customs of every country have fixed upon particular periods, on which they are presumed capable of acting with reason and discretion; in our law the full age of man or woman is 21 years. 3 Bac. Abr. 118.

The ages of male and female are different for different purposes: a male at 12 years of age may take the oath of allegiance; at 14 is at discretion, and therefore may consent or disagree to marriage; may choose his guardian, and if his discretion is actually proved, may make his testament of his personal estate; at 17 he may be a procurator or an executor; and at 21 is at his own disposal, and may alien his lands, goods, and chattels. A female at seven years of age may be betrothed or given in marriage; at nine is entitled to dower; and at 12 is of years of maturity, and therefore may consent or disagree to marriage, and if proved to have sufficient discretion may bequeath her personal estate; at 14 is at years of legal discretion, and may choose a guardian; at 17 may be executrix; and at 21 may dispose of herself and her lands. 1 Black. 463.

An infant is capable of inheriting, for the law presumes him capable of property; also an infant may purchase, because it is intended for his benefit, and the freehold is in him till he disagrees thereto, because an agreement is presumed, it being for his benefit, and because the freehold cannot be in the grantor contrary to his own act, nor can be in abeyance, for then a stranger would not know against whom to demand his right; and if at his full age the infant agrees to the purchase, he cannot afterwards avoid it; but if he dies during his minority his heirs may avoid it, for they shall not be bound by the contracts of a person who wanted capacity to contract. Co. Litt. 2.

As to infants being witnesses, there seems to be no fixed time at which children are excluded from giving evidence; but it will depend in a great measure on the sense and understanding of the children, as it shall appear on examination in court. Bull. N. P. 293.

And where they are admitted, concurrent testimony seems peculiarly desirable. 4 Bla. 214.

An infant is not bound by his contract to deliver a thing; so if one deliver goods to an infant upon a contract, &c. knowing him to be an infant, he shall not be chargeable in trover and conversion, or any other action for them; for the infant is not capable of any contract but for necessaries, therefore such delivery is a gift to the infant; but if an infant, without any contract, wilfully takes away the goods of another, trover lies against him; also it is said, that if he takes the goods under pretence that he is of full age, trover lies, because it is a wilful and fraudulent trespass. 1 Sid. 129.

Infants are disabled to contract for any thing but neces-

saries for their person, suitable to their degree and quality; and what is necessary must be left to the jury. Co. Litt. 172.

An infant, knowing of a fraud, shall be as much bound as if of age. 13 Vin. Abr. 536.

But it is held that this rule is confined to such acts only as are voidable; and that a warrant of attorney given by an infant being absolutely void, the court will not confirm it, though the infant appeared to have given it, knowing it was not good, and for the purpose of collusion.

As to acts of infants being void, or only voidable, there is a diversity between an actual delivery of the thing contracted for, and a bare agreement to deliver it; the first is voidable, but the last absolutely void.

As necessaries for an infant's wife are necessaries for him, he is chargeable for them, unless provided before marriage; in which case he is not answerable, though she wore them afterward. 1 Str. 168.

An infant is also liable for the nursing of his lawful child.

Where goods are furnished to the son, he is himself liable if they are necessaries. If tradesmen deal with him, and he undertakes to pay them, they must resort to him for payment; but if they furnished the infant on the credit of his father, the father only is liable. 2 Esp. 471.

With respect to education, &c. infants may be charged, where the credit was given bona fide to them. But where the infant is under the parent's power, and living in the house with them, he shall not be liable even for necessaries. 2 Black. Rep. 1325.

If a taylor trusts a young man, under age, for clothes to an extravagant degree, he cannot recover; and he is bound to know whether he deals at the same time with any other taylor. 1 Esp. Rep. 212.

If one lends money to an infant to pay a debt for necessaries, and he pays it, although he is not bound in law, it is said he is in equity; but if the infant misapplies the money it is at the peril of the lender.

A promissory note given by an infant for board and lodging. and for teaching him a trade, is valid, and will support an action for the money. 1 T. R. 41.

And debts contracted during infancy are good considerations to support a promise made to them when a person is of full age; but the promise must be express.

A bond without a penalty for necessaries will bind an infant, but not a bond with a penalty. Esp. Rep. 164.

Legacies to infants cannot be paid either to them or their parents.

An infant cannot be a juror, neither can he be an attorney, bailiff, factor, or receiver. Co. Lit. 172.

By the custom of London an infant unmarried, and above the age of 14, if under 21, may bind himself apprentice to a freeman of London, by indenture with proper covenants, which covenants, by the custom of London, will be as binding as if of age.

If an infant draws a bill of exchange, yet he shall not be liable on the custom of merchants; but he may plead infancy in the same manner as he may to any other contract.

An infant cannot be sued but under the protection and joining the name of his guardian; but he may sue either by his guardian, or his next friend, who is not his guardian. Co. Lit. 135.

An action on an account stated will not lie against an infant, though it should be for necessaries. Co. Lit. 172.

INFINITE, or INFINITELY GREAT LINE, in geometry, denotes only an indefinite or indeterminate line, to which no certain bounds, or limits, are prescribed.

INFINITESIMALS, among mathematicians, are defined to be infinitely small quantities.

In the method of infinitesimals, the element, by which any quantity increases or decreases, is supposed to be infinitely small, and is generally expressed by two or more terms, some of which are infinitely less than the rest, which being neglected as of no importance, the remaining terms form what is called the difference of the proposed quantity. The terms that are neglected in this manner, as infinitely less than the other terms of the element, are the very same which arise in consequence of the acceleration, or retardation, of the generating motion, during the infinitely small time in which the element is generated; so that the remaining terms express the elements that would have been produced in that time, if the generating motion had continued uniform: therefore those differences are accurately in the same ratio to each other as the generating motions or fluxions. And hence, though in this method infinitesimal parts of the elements are neglected, the conclusions are accurately true without even an infinitely small error, and agree precisely with those that are deduced by the method by fluxions.

For example, (see Plate LXXII. Miscel. fig. 136), when DG, the increment of the base AD, of the triangle ADE, is supposed to become infinitely little, the trapezium DGHE (the simultaneous increment of the triangle) consists of two parts, the parallelogram EG, and the triangle EIH; the latter of which is infinitely less than the former, their ratio being that of one-half DG to AD: therefore, according to this method in fluxions, the part EIH is neglected, and the remaining part, viz. the parallelogram EG, is the difference of the triangle ADE. Now it might be shown, that EG is precisely that part of the increment of the triangle ADE which is generated by the motion with which the triangle flows, and that EIH is the part of the same increment which is generated in consequence of the acceleration of this motion, while the base, by flowing uniformly, acquires the augment DG, whether DG be supposed finite or infinitely less.

Example 2. The increment DELMHG (fig. 137) of the rectangle AE, consists of the parallelograms EG, EM, and I*h*; the last of which, I*h*, becomes infinitely less than EG, or EM, when DG and LM, the increments of the sides, are supposed infinitely small; because I*h* is supposed to be to EG as LM to AL, and to EM as DG to AD; therefore, I*h* being neglected, the sum of the parallelograms EG and EM is the difference of the rectangle AE: and the sum of EG and EM is the space that would have been generated by the motion with which the rectangle AE flows continued uniformly, but that I*h* is the part of the increment of the rectangle which is generated in consequence of the acceleration of this motion, in the time that AD and AL, by flowing uniformly, acquire the augments DG and LM. The same may be observed in propositions wherein the fluxions of quan-

tities are determined; and thus the manner of investigating the differences, or fluxions of quantities, in the method of infinitesimals, may be deduced from the principles of the method of fluxions. For instead of neglecting EIH because it is infinitely less than EG, (according to the usual manner of reasoning in that method), we may reject it; because we may thence conclude, that it is not produced in consequence of the generating motion DG, but of the subsequent variations of this motion. And it appears why the conclusions in the method of infinitesimals are not to be represented as if they were only near the truth, but are to be held as accurately true.

In order to render the application of this method easy, some analogons principles are admitted, as that the infinitely small elements of a curve are right lines, or that a curve is a polygon of an infinite number of sides, which being produced, give the tangents of the curve; and by their inclination to each other measure the curvature. This is as if we should suppose, when the base flows uniformly, the ordinate flows with a motion which is uniform for every infinitely small part of time, and increases or decreases by infinitely small differences at the end of every such time.

But however convenient this principle may be, it must be applied with caution and art on various occasions. It is usual therefore, in many cases, to resolve the element of the curve into two or more infinitely small right lines; and sometimes it is necessary, if we would avoid error, to resolve it into an infinite number of such right lines, which are infinitesimals of the second order. In general, it is a postulatum in this method, that we may descend to the infinitesimals of any order whatever, as we find it necessary; by which means any error that might arise in the application of it may be discoverd and corrected by a proper use of this method itself. For an example of this, see Maclaurin's Fluxions.

INFLAMMABILITY, that property of bodies which disposes them to kindle or catch fire. See CALORIC, CHEMISTRY, &c.

INFLAMMATION. See SURGERY and MEDICNE.

INFLECTION, or *point of inflection*, in the higher geometry, is the point where a curve begins to bend a contrary way. See FLEXURE.

To determine the point of inflection in curves, whose semi-ordinates CM, Cm (Pl. LXXII. Misc. fig. 134) are drawn from the fixed point C; suppose CM to be infinitely near Cm, and make mH = Mm; let Tm touch the curve in M. Now the angle CmT, CMm, are equal; and so the angle CmH, while the semi-ordinates increase, does decrease, if the curve is concave towards the centre C, and increases if the convexity turns towards it. Whence this angle, or, which is the same, its measure, will be a minimum or maximum, if the curve has a point of inflection or retrogression; and so may be found, if the arch TH, or fluxion of it, be made equal to 0, or infinity. And in order to find the arch TH, draw mL, so that the angle TmL be equal to mCL; then if CM $= y$, $mr = x$, mT $= \dot{t}$, we shall have $y : \dot{x} :: \dot{t} : \frac{\dot{t}\dot{x}}{y}$. Again, draw the arch HO to the radius CH; then the small right lines mr, OH, are parallel; and so the triangles OLH, mLr, are similar; but because HI is also perpendicular to mL, the triangles LHI, mLr, are also similar: whence $\dot{t} : \dot{x} :: y : \frac{\dot{x}\ddot{y}}{\dot{t}}$; that is, the quantities mT, mL, are equal. But HL is the fluxion of Hr, which is the distance of C$m = y$; and HD is a negative quantity, because while the ordinate CM increases, their difference rH decreases; whence $\dot{x}x + \dot{y}y - \dot{y}y = 0$, which is a general equation for finding the point of inflection, or retrogradation. See FLUXIONS.

INFORMATION, in law. An information may be defined an accusation or complaint exhibited against a person for some criminal offence, either immediately against the king, or against a private person, which, from its enormity or dangerous tendency, the public good requires should be restrained and punished. It differs principally from an indictment in this, that an indictment is an accusation found by the oath of 12 men, but an information is only the allegation of the officer who exhibits it. 3 Bac. Abr. 164.

Informations are of two kinds: first, those which are partly at the suit of the king, and partly at the suit of a subject; and, secondly, such as are only in the name of the king: the former are usually brought upon penal statutes, which inflict a penalty on conviction of the offender, one part to the use of the king, and another to the use of the informer; and are called qui tam, or popular actions, only carried on by a criminal instead of a civil process.

Informations that are exhibited in the name of the king alone are also of two kinds: first, those which are truly and properly his own suits, and filled ex officio by his own immediate officer, the attorney-general; secondly, those in which, though the king is the nominal prosecutor, yet it is at the relation of some private person, or common informer; and they are filed by the master of the crown office, under the express direction of the court. The objects of the king's own prosecutions, filed ex officio by the attorney-general, are properly such enormous misdemeanours as peculiarly tend to disturb or endanger the government. The objects of the other species of informations, filed by the master of the crown office, upon the complaint or relation of a private subject, are any gross and notorious misdemeanors, riots, batteries, libels, or other immoralities, of an atrocious kind, not peculiarly tending to disturb the government, but which, on account of their magnitude or pernicious example, deserve the most public animadversion. And when an information is filed either thus, or by the attorney-general ex officio, it must be tried by a petty jury of the county where the offence arises; after which, if the defendant is found guilty, he must resort to the court of king's bench for his punishment. 4 Black. 308.

If a common informer should willingly delay his suit, or discontinue, or he non suited, or shall have a verdict or judgment against him, he shall pay costs to the defendant. 18 Eliz. c. 5.

And in the court of king's bench, particularly if the defendant shall appear and plead to issue, and the prosecutor shall not at his own costs, within a year after issue joined, procure the same to be tried; or if a verdict pass for the defendant, or the informer procure a noli prosequi to be entered; the said court of king's bench

may award the defendant his costs, unless the judge shall certify that there was a reasonable cause for exhibiting such information; and if the informer shall not, in three months after such costs taxed, and demand made, pay the same, the defendant shall have the benefit of the recognizance, to compel him thereunto. 4 and 5 W. c. 18.

INFRALAPSARIANS, in church history. an appellation given to such predestinarians as think the decrees of God, in regard to the salvation and damnation of mankind, were formed in consequence of Adam's fall.

INFUSION, a method of obtaining the virtues of plants, roots, &c. by steeping them in a hot or cold liquid.

INFUSORIA, in natural history, minute simple animalcules, seldom visible to the naked eye. When water is examined with the microscope, particularly that which has long been stagnant, and has vegetable matter growing in it, or water in which vegetables have been infused, thousands of minute animals have been discovered, which have been arranged together in this order. When wheat that is rickety is infused in water, small eel-shaped worms are discovered, which were the cause of the disease. Wheat thus injured is very different from smutty wheat. The grains are brown, shrivelled, and of irregular forms; each contains one or more of these worms, which lie dormant as long as the grain is dry; but as soon as it is moistened by being sown, or otherwise, the worms are revivified, feed on the flour, and lay their eggs. If such grain vegetates, the young as soon as they are hatched, eat their way up the stem, and bury themselves in the young succulent ear.

INGRESS, in astronomy, signifies the sun's entering the first scruple of one of the four cardinal signs, especially Aries.

INGROSSER. See FORESTALLING.

INHALER, in medicine, a machine for steaming the lungs with warm water, recommended by Mr. Mudge in the cure of the catarrhous cough. The body of the instrument resembles a porter-pot, holds about a pint, and the handle, which is fixed to the side of it, is hollow. In the lower part of the vessel, where it is soldered to the handle, is a hole, by means of which and three others on the upper part of the handle, the water, when it is poured into the inhaler, will rise to the same level in both. To the middle of the cover a flexible leathern tube, about six or seven inches long, is fixed, with a mouth-piece of wood or ivory. In the cover there is a valve fixed, which opens and shuts the communication between the upper and internal part of the inhaler and external air. This valve is extremely simple: being formed only of a short tube descending inwards from the cover, and having beneath a small hole upon which a ball of cork plays. When the mouth is applied to the end of the tube in the act of inspiration, the air rushes into the handle, and up through the body of warm water, and the lungs become, consequently, filled with hot vapour. In exspiration, the mouth being still fixed to the tube, the breath, together with the steam on the surface of the water in the inhaler, is forced up through the valve in the cover.

INHERITANCE, is a perpetuity in lands or tenements to a man and his heirs; and the word inheritance is not only intended where a man has lands or tenements by descent, but also every fee-simple, or fee-tail, which a person has by purchase, may be said to be an inheritance, because his heirs may inherit it. Lit. s. 9.

Inheritances are corporeal or incorporeal. Corporeal inheritances relate to houses and lands, which may be touched or handled; and incorporeal hereditaments are rights issuing out of, annexed to, or exercised with, corporeal inheritances; as advowsons, tithes, annuities, offices, commons, franchises, privileges, and services. 1 Inst. 49.

There are several rules of inheritances of lands, according to which estates are transmitted from ancestor to heir, viz. 1. That inheritances shall lineally descend to the issue of the person last actually seized, in infinitum, but shall never lineally ascend. 2. The male issue shall be admitted before the female. 3. Where there are two or more males in equal degree the eldest only shall inherit; but the females all together. 4. The lineal descendants, in infinitum, of any person deceased shall represent their ancestor; that is, shall stand in the same place as the person himself would have done had he been living: thus the child, grandchild, or great-grandchild (either male or female), of the eldest son, succeeds before the younger son, and so infinitum. 5. On failure of issue of the person last seized, the inheritance shall descend to the blood of the first purchaser. 6. The collateral heir of the person last seized must be his next collateral kinsman of the whole blood. 7. In collateral inheritances the male stocks shall be preferred to the female, unless where lands are descended from a female: thus the relations on the father's side are admitted in infinitum before those on the mother's side are admitted at all; and the relations of the father's father before those of the father's mother, and so on. 2 Black. c. 14.

INHIBITION, a writ to inhibit or forbid a judge from farther proceedings in the cause depending before him. F. N. B. 39.

INJUNCTION. An injunction is a prohibitory writ, restraining a person from committing or doing a thing which appears to be against equity and conscience. 3 Bac. Abr. 172.

An injunction is usually granted for the purpose of preserving property in dispute pending a suit; as to restrain the defendant from proceedings at the common law against the plaintiff, or from committing waste, or doing any injurious act. Milf. Treat. Chan. Plead.

Injunctions issue out of the courts of equity in several instances. The most usual injunction is to stay proceedings at law; as, if one man brings an action at law against another, and a bill is brought to be relieved either against a penalty, or to stay proceedings at law, or some equitable circumstances, of which the party cannot have the benefit at law. In such case the plaintiff in equity may move for an injunction either upon an attachment, or praying a dedimus, or praying a farther time to answer; for it being suggested in the bill that the suit is against conscience, if the defendant is in contempt for not answering, or prays time to answer, it is contrary to conscience to proceed at law in the mean time; and therefore an injunction is granted of course: but this injunction only stays execution touching the matter in question; and there is always a clause giving liberty to call for a plea to proceed to trial, and

for want of it to obtain judgment; but execution is stayed till answer, or farther order. 3 Bac. Abr. 178.

When a bill in chancery is filed in the office of the six clerks, if an injunction is prayed therein, it may be had, at various stages of the cause, according to the circumstances of the case. If the bill is to stay execution upon an oppressive judgment, and the defendant does not put in his answer within the time allowed by the rules of the court, an injunction will issue of course; and when the answer comes in, the injunction can only be continued upon a sufficient ground appearing from the answer itself. But if an injunction is wanted to stay waste, or other injuries of an equally unjust nature, then upon the filing of the bill, and a proper case supported by affidavits, the court will grant an injunction immediately; to continue till the defendant has put in his answer, and till the court shall make some further order concerning it; and when the answer comes in whether it shall then be dissolved, or continued till the hearing of the cause, is determined by the court upon argument, drawn from considering the answer and affidavits together. 3 Bla. 443.

The method of dissolving injunctions are various; when the answer comes in, and the party has cleared his contempt by paying the costs of the attachment, if there is one, he obtains an order to dissolve nisi, and serves it on the plaintiff's clerk in court: this order takes notice of the defendant's having fully answered the bill, and thereby denied the full equity thereof, and being regularly served, the plaintiff must show cause at the day; or the defendant's counsel, where there is no probability of showing cause, may move to make the order absolute, unless cause, sitting the court. 3 Bac. Abr. 177.

If the plaintiff who has an injunction die pending the suit, in strictness the whole proceedings are abated, and the injunction with them; but even in this case the party shall not take out execution without special leave of the court; he must move the court for the plaintiff to revive his suit within a limited time, or the injunction to stand dissolved; and as this is never denied, so if the suit is not revived, the party takes out execution. There are some instances where a plaintiff may move to revive his injunction; but as that rarely happens, so it is rarely granted, especially where the injunction has been before dissolved; but where a bill is dismissed, the injunction and every thing else are gone, and execution may be taken out the next day. 3 Bac. Abr. 178.

INJURY, a wrong or damage to a man's person or goods. The law will suffer a private injury rather than a public evil; and the act of God or the law does injury to none. 4 Rep. 124.

INK. There are two principal kinds of ink, writing and printing ink.

Writing-ink. When to an infusion of gall-nuts some solution of sulphate of iron (green copperas) is added, a very dark blue precipitate takes place. This precipitate is the gallic acid of the galls united to the iron of the green vitriol, forming gallat of iron, which is the basis of writing-ink. If galls and sulphate of iron only were used, the precipitate would fall down, leaving the water colourless; and in order to keep it suspended in the water, forming a permanently black, or rather a very dark blue fluid, gum arabic is added, which, by its viscid nature, prevents the precipitate from falling down.

Various receipts have been given for the composition of writing-ink, but very few have been founded upon a knowledge of its real nature. The receipt given by M. Rihancourt is as follows: Take eight ounces of Aleppo galls, in coarse powder; four ounces of logwood, in thin chips; four ounces of sulphate of iron (green copperas); three ounces of gum arabic in powder; one ounce of sulphate of copper (blue vitriol); and one ounce of sugar-candy. Boil the galls and logwood together in twelve pounds of water for one hour, or till half the liquid has been evaporated. Strain the decoction through a hair sieve, or linen cloth, and then add the other ingredients. Stir the mixture till the whole is dissolved, more especially the gum; after which leave it to subside for 24 hours. Then decant the ink, and preserve it in bottles of glass or stone ware, well corked.

The following will also make a good ink: To one quart of soft water add four ounces of galls, one ounce of copperas roughly bruised, and two ounces of gum arabic. Let the whole be kept near the fire a few days, and occasionally well shaken.

Red writing-ink is made in the following manner: Take of the raspings of Brazil wood a quarter of a pound, and infuse them two or three days in vinegar. Boil the infusion for an hour over a gentle fire, and afterwards filtre it while hot. Put it again over the fire, and dissolve in it, first, half an ounce of gum arabic; and afterwards of alum and white sugar, each half an ounce.

Printing-ink is a black paint, composed of lampblack and linseed or suet oil boiled, so as to acquire considerable consistence and tenacity. The art of preparing it is kept a secret; but the obtaining good lampblack appears to be the chief difficulty in making it.

The ink used by copper-plate printers differs from the last only in the oil not being so much boiled, and the black which is used being Frankford black.

Sympathetic inks are such as do not appear after they are written with, but which may be made to appear at pleasure, by certain means to be used for that purpose. A variety of substances have been used for this purpose. We shall describe the best of them.

1. Dissolve some sugar of lead in water, and write with the solution. When dry, no writing will be visible. When you want to make it appear, wet the paper with a solution of alkaline sulphuret (liver of sulphur), and the letters will immediately appear of a brown colour. Even exposing the writing to the vapours of these solutions will render it apparent.

2. Write with a solution of gold in aqua regia, and let the paper dry gently in the shade. Nothing will appear; but draw a sponge over it wetted with a solution of tin in aqua regia, the writing will immediately appear of a purple colour.

3. Write with an infusion of galls, and when you wish the writing to appear, dip it into a solution of green vitriol; the letters will appear black.

4. Write with distilled sulphuric acid, and nothing will be visible. To render it so, hold it to the fire, and the letters will instantly appear black.

5. Juice of lemons, or onions, a solution of sal ammo-

niac, green vitriol, &c. will answer the same purpose, though not so easily, nor with so little heat.

6. Green sympathetic ink. Dissolve cobalt in nitro-muriatic acid, and write with the solution. The letters will be invisible till held to the fire, when they will appear green, and will disappear completely again when removed into the cold. In this manner they may be made to appear and disappear at pleasure.

A very pleasant experiment of this kind is to make a drawing representing a winter scene, in which the trees appear void of leaves, and to put the leaves on with this sympathetic ink; then, upon holding the drawing near to the fire, the leaves will begin to appear in all the verdure of spring, and will very much surprise those who are not in the secret.

7. Blue sympathetic ink. Dissolve cobalt in nitric acid; precipitate the cobalt by potass; dissolve this precipitated oxide of cobalt in acetic acid, and add to the solution one-eighth of common salt. This will form a sympathetic ink, that, when cold, will be invisible, but will appear blue by heat.

INK, *removing stains of.* The stains of ink on cloth, paper, or wood, may be removed by almost all acids; but those acids are to be preferred which are least likely to injure the texture of the stained substance. The muriatic acid, diluted with five or six times its weight of water, may be applied to the spot, and, after a minute or two, may be washed off, repeating the application as often as may be found necessary. But the vegetable acids are attended with less risk, and are equally effectual. A solution of the oxalic, citric (acid of lemons), or tartareous acids, in water, may be applied to the most delicate fabrics without any danger of injuring them; and the same solutions will discharge writing, but not printing-ink. Hence they may be employed in cleaning books which have been defaced by writing on the margin, without impairing the text. Lemon-juice, and the juice of sorrel, will also remove ink-stains, but not so easily as the concrete acid of lemons, or citric acid.

INNS AND INNKEEPES. Common inns were instituted for passengers; and the duty of inkeepers extends chiefly to the entertaining and harbouring of travellers, finding them victuals and lodging, and securing the goods and effects of their guests; and therefore if one who keeps a common inn refuses either to receive a traveller as a guest into his house, or to find him victuals or lodging, upon his tendering a reasonable price for the same, he is not only liable to render damages for the injury in an action on the case, at the suit of the party grieved, but also may be indicted and fined at the suit of the king. Dyer, 158.

In return for such responsibility the law allows him to retain the horse of his guest until paid for his keep; but he cannot retain such horse for the bill of the owner, although he may retain his goods for such bill; neither can he detain one horse for the food of another. 1 Bulst. 207, 217.

An innkeeper, however, is not bound to receive the horse, unless the master lodge there also. 2 Brown, 254.

Neither is a landlord bound to furnish provisions unless paid beforehand. 9 Co. 87.

If an innkeeper makes out unreasonable bills, he may be indicted for extortion; and if either he or any of his servants knowingly sell bad wine or bad provisions, they will be responsible in an action of deceit.

Any person may set up a new inn, unless it is inconvenient to the public, in respect of its situation, or to its increasing the number of inns, not only to the prejudice of other ancient and well-governed inns: for the keeping of an inn is no franchise, but a lawful trade, open to every subject, and therefore there is no need of any licence from the king for that purpose. 2 Roll. Abr. 84.

An innkeeper is distinguished from other trades in that he cannot be a bankrupt; for though he buys provisions to be spent in his house, yet he does not properly sell them, but utter them at such rates as he thinks reasonable; and the attendance of his servants, furniture of his house, &c. are to be considered; and the statutes of bankruptcy only mention merchants that use to buy and sell in gross, or buy retail, and such as get their living by buying and selling; but the contracts with innkeepers are not for any commodities in specie, but they are contracts for house-room, trouble, attendance, lodging, and necessaries, and therefore cannot come within the design of such words, since there is no trade carried on by buying and bartering commodities. 1 Jones, 437.

But where an innkeeper is a chapman also, and buys and sells, he may, on that account, be a bankrupt, though not barely as an innkeeper, and this has been frequently seen. 7 Vin. Abr. 57.

Innkeepers are clearly chargeable for the goods of guests stolen or lost out of their inns, and this without any contract or agreement for that purpose; for the law makes them liable in respect of the reward, as also in respect of their being places appointed and allowed by law, for the benefit and security of traders and travellers. Dyer, 266.

But if a person comes to an innkeeper, and desires to be entertained by him, which the inkeeper refuses, because his house is already full; whereupon the party says he will shift among the rest of his guests, and there he is robbed, the host shall not be charged. Dyer, 158.

If a man comes to a common inn to harbour, and desires that his horse may be put to grass, and the host put him to grass accordingly, and the horse is stolen, the host shall not be charged; because by law the host is not bound to answer for any thing out of his inn, but only for those that are infra hospitium. 8 Co. 32 b.

Innkeepers may detain the person of the guest who eats, or the horse which eats, till payment, and this he may do without any agreement for that purpose; for men that get their livelihood by entertainment of others, cannot annex such disobliging conditions, that they should retain the party's property in case of non-payment, nor make such disadvantageous and impudent a supposition, that they shall not be paid; and therefore the law annexed such a condition without the agreement of the parties. Roll. Abr. 85.

By the custom of London and Exeter, if a man commits a horse to a hostler, and he eats out the price of his head, the hostler may take him as his own, upon the reasonable appraisement of four of his neighbours; but the innkeeper has no power to sell the horse, by the general custom of the whole kingdom. Moor. 876. 3 Bulst. 271.

But it has been held, that though an innkeeper in

London may, after long keeping, have the horse appraised, and sell him; yet when he has, in such case, had him appraised, he cannot justify the taking him to himself, at the price it was appraised at. 1 Vin. Abr. 233.

INNS OF COURT, are so called, because the students therein study the law, to enable them to practise in the courts at Westminster, or elsewhere; and also because they use all other gentle exercises, as may render them better qualified to serve the king in his court. Fortesq. c. 49.

INNOMINATA OSSA. See ANATOMY.

INNUENDO, is a word used in declarations and law proceedings, to ascertain a person or thing which was named before; as to say he (innuendo the plaintiff) did so and so, when there was mention before of another person.

Innuendo may serve for an explanation where there is precedent matter, but never for a new charge; it may apply what is already expressed, but cannot add or enlarge the importance of it. 2 Salk. 513.

INOCULATION. See MEDICINE.

INOCULATION, or *Budding*. See GRAFTING.

INOLITHUS, in mineralogy, a stone consisting of carbonate of lime, carbonic acid gas, and a little iron; entirely soluble in nitric acid with effervescence; fibrous, parasitic, soft, lightish, breaking into indeterminate fragments. There are several species: of the filamentosius there are three varieties; the satin spar, so called from its rich satiny lustre, is found in Russia, Poland, Germany, Saxony, and Bohemia, with the fibres straight and a little curved. It is found also about a mile from Alston in Cumberland, washed by the river Tyne, near the level of its bed; colour white, with sometimes a rosy tinge from a diluted oxide of iron, and transmits light from the edges, or in thinner pieces: fracture in the direction of the striæ fibrous, straight or curved; specific gravity about 2.71, contains carbonic acid 47, carbonate of lime 50, water crystallization 2, and a small portion of iron.

INORDINATE PROPORTION, is where there are three magnitudes in one rank, and three others proportional to them in another, and you compare them in a different order. Thus suppose the numbers in one rank to be 2, 3, 9; and those of the other rank 8, 24, 36; which are compared in a different order, viz. 2 : 3 : : 24 : 36; and 3 : 9 : : 8 : 24. Then rejecting the mean terms of each rank, you conclude 2 : 9 : : 8 : 36.

INQUEST, in law, signifies an inquiry made by a jury, in a civil or criminal cause, by examining witnesses. There is also an inquest of office, used for the satisfaction of the judges, and sometimes to make an inquiry, whether a criminal is a lunatic or not; upon which inquest, if it is found that the criminal only feigns himself to be a lunatic, and at the same time refuses to plead, he may be dealt with as one standing mute. Where a person is attainted of felony, and escapes, and afterwards, on being retaken, denies that he is the same man, inquest must be made into the identity of the person by a jury, before he can be executed.

INQUISITION, in law, a manner of proceeding by way of search or examination used on the king's behalf, in cases of outlawry, treason, felony, self-murder, &c. to discover lands, goods, and the like, forfeited to the crown. Inquisition is also had upon extents of lands, tenaments, &c. writs of elegit, and where judgment being had by default, damages and costs are recovered.

INQUISITION, in the church of Rome, a tribunal in several Roman-catholic countries, erected by the popes for the examination and punishment of heretics.

This court was founded in the 12th century by father Dominica and his followers, who were sent by pope Innocent III. with orders to excite the catholic princes and people to extirpate heretics, to search into their number and quality, and to transmit a faithful account thereof to Rome. Hence they were called inquisitors; and this gave birth to the formidable tribunal of the inquisition, which was received in all Italy, and the dominions of Spain, except the kingdom of Naples, and the Lower-countries. See ACT OF FAITH.

INROLLMENT, in law, is the registering, recording, or entering in the rolls of the chancery, king's-bench, common-pleas, or exchequer, or by the clerk of the peace in the records of the quarter-sessions, of any lawful act; a statute of recognizance acknowledges a deed of bargain and sale of lands, and the like; but the inrolling a deed does not make it a record, though it thereby becomes a deed recorded; for there is a difference between a matter of record and a thing recorded to be kept in memory; a record being the entry in parchment of judicial matters controverted in a court of record, and whereof the court takes notice, whereas an inrollment of a deed is a private act of the parties concerned, of which the court takes no cognizance at the time of doing it, although the court permits it. 2 Lill. Abr. c. 9.

By stat. 27 H. VIII. c. 16, no lands shall pass, whereby any estate of inheritance or freehold shall take effect, or any use thereof be made, by reason only of any bargain and sale thereof, except the bargain and sale is made by writing indented, sealed, and within six months inrolled within one of the king's courts of record at Westminster; or else within the county where the lands lie, before the clerk of the peace, and one or more justices.

But by 5 Eliz. c. 26, in the counties palatine, they may be inrolled at the respective courts there, or at the assizes.

Every deed before it is inrolled is to be acknowledged to be the deed of the party, before a master of chancery, or a judge of the court wherein it is inrolled, which is the officer's warrant for inrolling the same; and the inrollment of a deed, if it is acknowledged by the grantor, will be a good proof of the deed itself upon trial. 2 Lill. Abr. 69.

But a deed may be inrolled without the examination of the party himself; for it is sufficient if oath is made of the execution. If two are parties, and the deed is acknowledged by one, the other is bound by it. And if a man lives abroad, and would pass lands in England, a nominal person may be joined with him in the deed, who may acknowledge it here, and it will be binding. 1 Salk. 389.

INSANITY. See MEDICINE.

INSCRIBED, in geometry. A figure is said to be inscribed in another when all its angles touch the sides or planes of the other figure.

INSECTS. See ENTOMOLOGY.

INSOLATION, in chemistry, a term made use of to

denote an exposure to the sun, to promote the chemical action of one substance upon another.

INSTALLMENT, the instating or establishing a person in some dignity. This word is chiefly used for the induction of a dean, prebendary, or other ecclesiastical dignitary, into the possession of his stall, or other proper seat in the cathedral to which he belongs. It is always used for the ceremony whereby the knights of the garter are placed in their rank in the chapel of St. George at Windsor, and on many other like occasions. It is sometimes termed installation.

INSTITUTES, in literary history, a book containing the elements of the Roman law, and constituting the last part of the civil law. The institutes are divided into four books, and contain an abridgment of the whole body of the civil law, being designed for the use of students.

INSTITUTION, in general, signifies the establishing or founding something.

In the canon and common law it signifies the investing a clerk with the spiritualities of a rectory, &c. which is done by the bishop, who uses the formula, "I institute you rector of such a church, with cure of souls, and receive your care and mine." This makes him a complete parson as to spirituality, but not as to temporality, which depends on induction. The term institutions is also used, in a literary sense, for a book containing the elements of any art or science: such are institutions of medicine, institutions of rhetoric, &c.

INSTRUMENT, in law, some public act or authentic deed, by which any truth is made apparent, or any right or title established in a court of justice. See DEED.

INSTRUMENTS, in music, are either played on by means of wind, as the organ, &c.; or by strings, as the violin, &c.

INSTRUMENTS, ASTRONOMICAL. We shall, under the word OBSERVATORY, give an account of the several instruments made use of in practical astronomy.

INSTRUMENTS, *mathematical.* A pocket case of mathematical instruments contains the following particulars, viz. 1. A pair of plain compasses. 2. A pair of drawing compasses, with its several parts. 3. A drawing-pen and pointer. 4. A protractor, in form of a semicircle, or sometimes of a parallelogram. 5. A parallel ruler. 6. A plain scale. 7. A sector, besides the black-lead pencil for drawing lines. The general uses of the above instruments are as follows: see Pl. LXXIII. Mathematical Instruments.

I. *Of the plain compasses,* Fig. 1. The use of the common or plain compasses is, (1.) to draw a blank line A B, by the edge of a ruler, through any other given point or points C D, &c. (2.) Take any extent or length between the points of the compasses, and to set it off, or apply it successively upon any line, as from C to D, fig. 2. (3.) To take any proposed line C D between the points, and, by applying it to the proper scale, to find its length. (4.) To set off equal distances upon a given line, by making a dot with the point at each, through which to draw parallel lines. (5.) To draw any blank circle, intersecting arches, &c. (6.) To lay off an angle of a given quantity upon an arch of a circle from the line of chords, &c. (7.) To measure any arch or angle, upon the chords, &c. (8.) To construct any proposed figure, in plotting or making plans, &c. by setting off the quantity of the sides and angles from proper scales. In short, the use of the compasses occurs in every branch of practical mathematics.

II. *Of the drawing-compasses.* These compasses are chiefly designated for drawing circles, and circular arches; and it is often necessary they should be drawn with different materials; and therefore this pair of compasses has, in one of its legs a triangnal socket, screw, to receive and fasten the following parts or points for that purpose. viz. (1.) A steel point, which being fixed in the socket, makes the compasses then but a plain pair, and has all the same uses as just now described in drawing blank circles, setting off lines, &c. (2.) A port-crayon with a black-lead pencil, cut to a fine point, for drawing lines that may be easily rubbed out again, if not right. A piece of slate-pencil may also be used in this part for drawing on slate. (3.) The dotting-point, or dotting-pen, with a small rowel, or indented wheel at the end, moving very freely; and receiving ink from the brass pen over it, communicates the same in equal and regular dots upon the paper, where dotted lines are chosen. (4.) The steel pen or point, for drawing and describing black lines with ink; for this purpose the two parts or sides of the pen are opened or closed with an adjusting screw, that the line drawn may be as fine or as coarse as you please.

In the port-crayon, dotter, and steel pen, there is a joint, by which you can set the lower part always perpendicular to the paper, which is necessary for drawing a line well, in every extent or opening of the compasses.

In some of the better sort of instruments, these points slide into the socket, and are kept tight by a spring on the inside that is not seen.

The steel point is sometimes made with a joint, and furnished with a fine spring and screw; by which, when you have opened the compasses nearly to the extent required, you can, by turning the screw, move the point to the true extent as it were, to a hair's breadth; which is the reason these are called hair-compasses.

The common compasses, at large, are not altogether so well adapted for small drawings; and therefore a small sort called bows, are contrived to answer all such purposes; they consist only of a steel point and drawing-pen, with a joint, and of a small length, so that very small circles may be nicely drawn with them, as they are to be conveniently moved and turned about in the hand, by a short stem or shaft.

III. *Of the drawing pen and pencil.* The drawing-pen is only the common steel pen at the end of a brass rod, or shaft, of a convenient length, to be held in the hand for drawing all kinds of straight black lines by the edge of a rule. The shaft or handle has a screw in the middle part; and, when unscrewed, there is a fine steel round pin or point, by which you make as nice a mark or dot upon the paper as you please, for terminating your lines in curious draughts.

The black-lead pencil, if good, is of frequent use for drawing straight lines, and for supplying the place of the drawing-pen, where lines of ink are not necessary; it is also often substituted for the common pen in writing, figuring, &c. Because in all cases, if what be drawn with it be not right, or does not please, it may be very easily rubbed out with a piece of crumb-bread, or indian rubber, and the whole new-drawn.

IV. *Of the protractor.* The protractor is a semicircle of brass, ADB, divided into 180 degrees, and numbered each way from end to end of the semicircle by 10°, 20°, 30°, &c. The central line is the external edge of the protractor's diameter, or straight side, sloped down to the under side, and is generally called a fiducial edge; in the middle of which is a small line or fine notch in the very edge, for the centre of the protractor. The uses of the protractor are two: (1.) To measure any angle proposed. (2.) To lay down any angle required.

For example: suppose it required to find what number of degrees are contained in the angle ACB (fig. 4); you place the centre of the protractor upon the angular point C, and the fiducial edge exactly upon the line CA; then observe what number of degrees the line CB cuts upon the graduated limb of the protractor, and that will be the measure of the angle ACB as required.

Secondly, suppose it required to protract or lay off from the line AC, an angle ACB, equal to 35 degrees. To do this, you place the centre of the protractor upon the given point C, and the straight edge upon AC very exactly; then make a fine point or dot at 35 degrees on the limb at B, and the protractor being removed, you draw through B the straight line CB, and it will make the angle ACB required.

Protractors in form of a parallelogram, or long square, as *a* E F *b* fig. 3, are usually made in ivory or brass; are more exact than the common semicircular ones, for angles to 40 or 50 degrees, because at and about each end, the divisions (being farther from the centre) are larger.

V. *Of the parallel ruler.* The parallel ruler is so called, because as it consists of two straight rules, connected together by two brass bars, yet so as to admit a very free motion to each: the one rule must always move parallel-wise to the other, that is, one rule will be every where equidistant from the other, and by this means it becomes naturally fitted for drawing one or more lines parallel to, or equally distant from, any line proposed. The manner of doing which is thus:

Let it be required to draw a straight line parallel to a given line AB, and at the distance AC, from it. (fig. 5.) First open the rulers to a greater distance than AC, and place the edge of the rulers exactly on the line AB; then holding the other rule (or side) firmly on the paper, you move the upper rule down from A to the point C, by which (holding it fast) you draw the line CD, which will be parallel to the given line AB as required.

Many very useful problems in the mathematics are performed by this instrument, of which the following are examples.

Let it be required to find a fourth proportional to three right lines given, AB, BC, and AD (fig. 6). To do this, draw the lines AC, AE, making any angle at pleasure. Upon AC with the compasses set off the lines AB and BC; and upon AE set off the line AD; join DB, and parallel to it draw EC, then will DE be the fourth proportional required. For AB : BC : : AD : DE.

Again, suppose it required to divide any line, AB, as another line AC is divided (fig. 7). To do this, join the extremities of each line CB, and parallel to CB draw EI, EH, DG, through the given points DEF in the line AC; and by these lines the line AB will be divided exactly similar to the line AC.

The parallel ruler is seldom put into a case of instruments, but those of the larger and better sort; being generally sold by itself of various sizes, from 6 inches to 2 feet in length.

Of the plain scale. The lines generally drawn on the plain scale, are these following:

		Marked
I.	Lines of equal parts.	E. P.
II.	——— Chords.	Cho.
III.	——— Rhumbs.	Ru.
IV.	——— Sines.	Sin.
V.	——— Tangents.	Tan.
VI.	——— Secants.	Sec.
VII.	——— Half Tangents.	S. T.
VIII.	——— Longitude.	Long.
IX.	——— Latitude.	Lat.
X.	——— Hours.	Ho.
XI.	——— Inclinations.	In. Mer.

Of the lines of equal parts. Lines of equal parts are of two sorts, viz. simply divided, and diagonally divided.

1. Simply divided. Draw three lines parallel to one another, at unequal distances (fig. 8), and of any convenient length; divide this length into what number of equal parts is thought necessary, allowing some certain number of these parts to an inch, such as 2, $2\frac{1}{2}$, 3, $3\frac{1}{2}$, 4, $4\frac{1}{2}$, &c. which divisions distinguish by lines drawn across the three parallels. Divide the left-hand division into 10 equal parts, which distinguish by lines drawn across the lower parallels only; but for distinction's sake, let the fifth division be somewhat longer than the others: and it may not be inconvenient to divide the same left hand division into 12 equal parts, which are laid down on the upper parallel line, having the third, sixth, and ninth divisions distinguished by longer strokes than the rest, whereof that at the sixth division make the longest.

There are, for the most part, several of these simply divided scales put on rulers, one above the other, with numbers on the left hand, showing in each scale, how many equal parts an inch is divided into; such as 20, 25, 30, 35, 40, 45, &c. and are severally used, as the plan to be expressed should be larger or smaller.

The use of these lines of equal parts, is to lay down any line expressed by a number of two places or denominations, whether decimally or duodecimally divided; as leagues, miles, chains, poles, yards, feet, inches, &c. and their tenth parts, or twelfth parts; thus, if each of the divisions be reckoned 1, as 1 league, mile, chain, &c. then each of the subdivisions will express $\frac{1}{10}$ part thereof; and if each of the large divisions be called 10, then each small one will be 1; and if the large divisions be 100, then each small one will be 10, &c.

Therefore to lay off a line $8\frac{7}{10}$, 87, or 870 parts, let them be leagues, miles, chains, &c. set one point of the compasses on the 8th of the large divisions, counting from the left hand towards the right, and open the compasses, till the other point falls on the 7th of the small divisions, counting from the right hand toward the left, then are the compasses opened to express a line of $8\frac{7}{10}$ 87, or 870 leagues, miles, chains, &c. and bears such proportion in the plan, as the line measured does to the thing represented.

But if a length of feet and inches was to be expressed, the same large divisions may represent the feet, but the

inches must be taken from the upper part of the first division, which (as before noted) is divided into twelve equal parts.

Thus if a line of 7 feet 5 inches was to be laid down, set one point of the compass on the fifth division among the twelve, counting from the right hand towards the left, and extend the other to 7, among the large divisions: and that distance laid down in the plan, shall express a line of 7 feet 5 inches; and the like is to be understood of any other dimensions.

2. Diagonally divided. Draw eleven lines parallel to each other, and at equal distances; divide the upper of these lines into such a number of equal parts, as the scale to be expressed is intended to contain; and from each of these divisions draw perpendiculars through the eleven perallels (fig. 9): subdivide the first of these divisions into 10 equal parts, both in the upper and lower lines; then each of these subdivisions may be also subdivided into ten equal parts, by drawing diagonal lines; viz. from the 10th below, to the ninth above; from the ninth below to the eighth above; from the eighth below to the seventh above, &c. till from the first below to the 10th above, so that by these means one of the primary divisions on the scale will be divided into 100 equal parts.

There are generally two diagonal scales laid on the same plane or face of the ruler, one being commonly half the other (fig. 9.)

The use of the diagonal scale is much the same with the simple scale; all the difference is, that a plan may be laid down more accurately by it; because in this, a line may be taken of three denominations, whereas from the former, only two could be taken.

Now from this construction it is plain, if each of the primary divisions represent 1, each of the first subdivisions will express $\frac{1}{10}$ of 1; and each of the second subdivisions (which are taken on the diagonal lines, counting from the top downwards) will express $\frac{1}{10}$ of the former subdivisions or 100th of the primary divisions; and if each of the primary divisions express 10, then each of the first subdivisions will express 1, and each of the 2d, $\frac{1}{10}$; and if each of the primary divisions represent 100, then each of the first subdivisions will be 10, and each of the 2d will be 1, &c.

Therefore to lay down a line, whose length is expressed by 347, $34\frac{7}{10}$ or $3\frac{47}{100}$, whether leagues, miles, chains, &c.

On the diagonal line, joined to the 4th of the first subdivisions, count 7 downwards, reckoning the distance of each parallel 1; there set one point of the compass, and extend the other, till it falls on the intersection of the third primary division with the same parallel in which the other foot rests, and the compasses will then be opened to express a line of 347, $34\frac{7}{10}$, or $3\frac{47}{100}$, &c.

Those who have frequent occasion to use scales, perhaps will find, that a ruler with the 20 following scales on it, viz. 10 on each face, will suit more purposes than any set of simply divided scales hitherto made public, on one ruler.

One side.—The divisions to an inch.
10, 11, 12, $13\frac{1}{2}$, 15, $16\frac{1}{2}$, 18, 20, 22, 25.
Other side.—The divisions to an inch.
28, 32, 36, 40, 45, 50, 60, 70, 85, 100.

The left-hand primary division, to be divided into 10 and 12 and 8 parts; for these subdivisions are of great use in drawing the parts of a fortress, and of a piece of cannon.

It will here be convenient to show, how any plan expressed by right lines and angles, may be delineated by the scales of equal parts, and the protractor. Suppose three adjacent things in any right-lined triangle being given, to form the plan thereof.

Example. Let ABC (fig. 10,) be a triangular field, the side AB = 327 yards; AC = 208 yards; and the angle at A = $44\frac{1}{2}$ degrees.

Construction. Draw a line AB at pleasure; then from the diagonal scale take 327 between the points of the compasses, and lay it from A to B; set the centre of the protractor to the point A, lay off $44\frac{1}{2}$ degrees, and by that mark draw AC; take with the compasses from the same scale 208, lay it from A to C, and join C B; so shall the parts of the triangle A B C, in the plan, bear the same proportion to each other, as the real parts in the field do.

The side C B may be measured on the same scale from which the sides A B, A C, were taken; and the angles at B and C may be measured by applying the protractor to them.

If two angles and the side contained between them were given.

Draw a line to express the side (as before); at the ends of that line, point off the angles, as observed in the field; lines drawn from the ends of the given line through those marks, shall form a triangle similar to that of the field.

Five adjacent things, sides and angles, in a right-lined quadrilateral, being given, to lay down the plan thereof, fig. 11.

Example. Given $\angle$ A = 70°; AB = 215 links; $\angle$ B = 115°; BC = 596 links; $\angle$ C = 114°.

Construction. Draw A D at pleasure; from A draw A B, so as to make with A D an angle of 70°: make AB = 215 (taken from the scales); from B, draw B C, to make with A B an angle of 115°; make B C = 596; from C, draw C D, to make with C B an angle of 114°; and by the intersection of C D with A D, a quadrilateral will be formed similar to the figure in which such measures could be taken as are expressed in the example.

If three of the things were sides, the plan might be formed with equal ease.

Following the same method, a figure of many more sides may be delineated; and in this manner, or some other like to it, surveyors make their plans or surveys.

The remaining lines of the plain scale are thus constructed.

Describe a circumference with any convenient radius, and draw the diameters fig. 12 A B, D E, at right angles to each other; continue B A at pleasure towards F; through D, draw D G parallel to B F; and draw the chords B D, B E, A D, A E. Circumscribe the circle with the square H M N, whose sides H M, M N, shall be parallel to AB, E D.

1. *To construct the line of chords.* Divide the arc A D into 90 equal parts: mark the 10th divisions with the figures 10, 20, 30, 40, 50, 60, 70, 80, 90; on D, as a

centre, with the compasses, transfer the several divisions of the quadrantal arc, to the chord A D, which marked with the figures corresponding, will become a line of chords.

Note. In the construction of this, and the following scales, only the primary divisions are drawn; the intermediate ones are omitted, that the figure may not appear too much crowded.

2. *The line of rhumbs.* Divide the arc B E into 8 equal parts, which mark with the figures 1, 2, 3, 4, 5, 6, 7, 8, and divide each of those parts into quarters; on B, as a centre, transfer the divisions of the arc to the chord B E, which marked with the corresponding figures, will be a line of rhumbs.

3. *The line of sines.* Through each of the divisions of the arc A D, draw right lines parallel to the radius A C; and C D will be divided into a line of sines which are to be numbered from C to D for the right sines, and from D to C for the versed sines. The versed sines may be continued to 180 degrees by laying the divisions of the radius C D, from C to E.

4. *The line of tangents.* A ruler on C, and the several divisions of the arc A D, will intersect the line D G, which will become a line of tangents, and is to be figured from D to G, with 10, 20, 30, 40, &c.

5. *The line of secants.* The distances from the centre C to the divisions on the line of tangents being transferred to the line C F from the centre C, will give the divisions of the line of secants; which must be numbered from A towards F, with 10, 20, 30, &c.

6. *The line of half tangents (or the tangents of half the arcs.)* A ruler on E, and the several divisions of the arc A D, will intersect the radius C A, in the divisions of the semi or half tangents; mark these with the corresponding figures of the arc A D.

The semitangents on the plane scales are generally continued as far as the length of the ruler they are laid on will admit; the divisions beyond 90° are found by dividing the arc A E like the arc A D, then laying a ruler by E and these divisions of the arc A E, the divisions of the semitangents above 90 degrees will be obtained on the line C A continued.

7. *The line of longitude.* Divide A H into 60 equal parts; through each of these divisions, parallels to the radius A C, will intersect the arc A E, in as many points; from E as a centre, the divisions of the arc E A, being transferred to the chord E A, will give the divisions of the line of longitude.

The points thus found on the quadrantal arc, taken from A to E, belong to the sines of the equally increasing sexagenary parts of the radius; and those arcs reckoned from E, belong to the cosines of those sexagenary parts.

8. *The line of latitude.* A ruler on A, and the several divisions of the sines on C D, will intersect the arc BD, in as many points; on B as a centre, transfer the intersections of the arc B D, to the right line B D; number the divisions from B to D, with 10, 20, 30, &c. to 90; and B D will be a line of latitude.

9. *The line of hours.* Bisect the quadrantal arcs B D, B E, in a, b; divide the quadrantal arc ab into 6 equal parts (which gives 15 degrees for each hour), and each of these into 4 others (which will give the quarters). A ruler on C, and the several divisions of the arc ab, will intersect the line MN in the hour, &c. points which are to be marked as in the figure.

10. *The line of inclinations of meridians.* Bisect the arc E A in c; divide the quadrantal arc bc into 90 equal parts; lay a ruler on C and the several divisions of the arc bc, and the intersections of the line HM will be the divisions of a line of inclinations of meridians.

Of the sector. A sector is a figure formed by two radii of a circle, and that part of the circumference comprehended between the two radii.

The instrument called a sector, consists of two flat rulers moveable round an axis or joint; and from the centre of this joint several scales are drawn on the faces of the rulers.

The two rulers are called legs, and represent the radii of a circle; and the middle of the joint expresses the centre.

The scales generally put on sectors, may be distinguished into single, and double.

The single scales are such as are commonly put on plain scales, and from whence dimensions or distances are taken, as have been already directed.

The double scales are those which proceed from the centre; each scale is laid twice on the same face of the instrument, viz. once on each leg: from these scales, dimensions or distances are to be taken, when the legs of the instrument are in an angular position, as will be shown hereafter.

The SCALES *commonly put on the best* SECTORS *are,*

Single	1	a line of	Iches, each Inch divided into 8 and 10 parts.		
	2		Decimals, containing 100 parts.		
	3		Chords,	marked	Cho.
	4		Sines,		Sin.
	5		Tangents,		Tang.
	6		Rhumbs,		Rum.
	7		Latitude,		Lat.
	8		Hours,		Hou.
	9		Longitude,		Lon.
	10		Inclin. Merid.		In. Me.
	11		the Logarithms of Numbers,		Num.
	12		the Logarithms of Sines,		Sin.
	13		the Logarithms of Versed Sines,		V. Sin.
	14		the Logarithms of Tangents,		Tan.

Double	1	a line o	Lines, or of equal parts,	marked	Lin.
	2		Chords,		Cho.
	3		Sines,		Sin.
	4		Tangents to 45°,		Tan.
	5		Secants,		Sec.
	6		Tangents above 45°,		Tan.
	7		Polygons,		Pol.

The scales of lines, chords, sines, tangents, rhumbs, latitudes, hours, longitude, incl. merid. may be used, whether the instrument is shut or open, each of these scales being contained on one of the legs only. The scales of inches, decimals, log. numbers, log. sines, log. versed sines, and log. tangents, are to be used with the sector quite opened, part of each scale lying on both legs.

The double scales of lines, chords, sines, and lower tangents, or tangents under 45 degrees, are all of the same radius or length; they begin at the centre of the instrument, and are terminated near the other extremity of each leg; viz. the lines at the division 10, the chords at 60, the sines at 90, and the tangents at 45; the remainder of the tangents, or those above 45 degrees, are on other scales beginning at $\frac{1}{4}$ of the length of the former, counted from the centre, where they are marked with 45, and run to about 76°.

The secants also begin at the same distance from the centre, where they are marked with 0, and are from thence continued to as many degrees as the length of the sector will allow, which is about 75 degrees.

Each double scale, one being on each leg and proceeding from the centre, make an angle; and in an equal angular position are all the double scales, whether of lines, or of chords, or of sines, or of tangents to 45 degrees.

And the angles made by the scales of upper tangents, and of secants, are also equal; and sometimes these angles are made equal to those made by the other double scales.

The scales of polygons are put near the inner edge of the legs: their beginning is not so far removed from the centre, as the 60 on the chords is: where these scales begin, they are marked with 4, and from thence are figured backwards, or towards the centre, to 12.

From the disposition of the double scales, it is plain, that those angles which were equal to each other, while the legs of the sector were close, will still continue to be equal, although the sector be opened to any distance it will admit of.

We shall now illustrate the nature of this instrument by examples.

Let CL, CL, (fig. 13) be the two lines of lines upon the sector, opened to an angle LCL; join the divisions 4 and 4, 7 and 7, 10 and 10, by the dotted lines *a, b, c d*, LL. Then by the nature of similar triangles, it is CL, to C *b*, as L L to *a b*; and C L to C *d*, as L L to *cd*; and therefore *a b* is the same part of L L as C *b* is of C L. Consequently, if L L be 10, then *a b* will be 4, and *c d* will be 7 of the same parts.

And hence, though the lateral scale C L be fixed, yet a parallel scale LL, is obtainable at pleasure; and therefore though the lateral radius is of a determined length in the lines of chords, sines, tangents and secants, yet the parallel radius may be had of any size you want, by means of the sector, as far as its length will admit; and all the parallel sines, &c. peculiar to it; as will be evident by the following examples in each pair of lines.

Ex. 1. *In the lines of equal parts.* Having 3 numbers given, 4, 7, 16, to find out a 4th proportional. To do this, take the lateral extent of 16 in the line C L, and apply it parallel-wise, from 4 to 4, by a proper opening of the sector; then take the parallel distance from 7 to 7 in your compasses, and applying one foot in C, the other will fall on 28 in the line of lines C L, and is the number required; for 4 : 7 : : 16 : 28.

Ex. 2. *In the lines of chords.* Suppose it required to lay off an angle A C B, (fig. 4) equal to 35 degrees; then with any convenient opening of the sector, take the extent from 60 to 60, and with it (as radius) on the point C describe the arch A D indefinitely; then in the same opening of the sector take the parallel distance from 35 degrees to 35 degrees, and set it from A to B in the arch A D and draw A B, and it makes the angle at C required.

Ex. 3. *In the lines of sines.* The lines of sines, tangents, and secants, are used in conjunction with the lines of lines in the solution of all the cases of plain trigonometry; thus let there be given in the triangle A B C, (fig. 14) the side A B = 230; and the angle A B C = 36° 30′; to find the side A C. Here the angle at C is 53° 30′. Then take the lateral distance 230, from the line of lines, and make it a parallel from 53° 30′ to 53° 30′ in the line of sines; then the parallel distance between 36° 30′ in the same lines, will reach laterally from the centre to 170, 19 in the line of lines for the side A C required.

Ex. 4. *In the lines of tangents.* If instead of making the side B C radius (as before) you make A B radius; then A C which before was a sine, is now the tangent of the angle B; and therefore to find it, you use the lines of tangents, thus:

Take the lateral distance 230 from the line of lines, and make it a parallel distance on the tangent radius, viz. from 45° to 45°, then the parallel tangent from 36° 30′, to 36° 30′, will measure laterally on the line of lines 170, 19, as before, for the side A C.

Ex. 5. *In the lines of secants.* In the same triangle, in the base A B, and the angles at B and C given, as before, to find the side or hypothenuse B C. Here B C is the secant of the angle B.

Take the lateral distance 230 from the line of lines, and make it a parallel distance on the tangent radius or beginnings of the lines of secants; then the parallel secant of 60° 30′ will measure laterally on the line of lines 287, 12, for the length of B C as required.

Ex. 6. *In the lines of sines and tangents conjointly.* In the solution of spherical triangles, you use the line of sines and tangents only, as in the following example. In the spherical triangle A B C (fig. 15) right-angled at A, there are given the side A B = 36° 15′, and the adjacent angle B = 42° 34′, to find the side A C. The analogy is radius: sine of A B : : tangent of B : tangent of AC;

therefore make the lateral sine of 36° 15′ a parallel at radius, or between 90 and 90; then the parallel tangent of 42° 34′ will give the lateral tangent of 28° 30′ for the side A C.

Ex. 7. *In the lines of polygons.* It has been observed that the chord of 60 degrees is equal to radius; and 60° is the sixth part of 360°; therefore such a chord is the side of a hexagon, inscribed in a circle: so that in the line of polygons, if you make the parallel distance between 6 and 6, the radius of a circle, as A C (fig. 16), then if you take the parallel distance between 5 and 5, and place it from A to B, the line A B will be the side of a pentagon A B D E F, inscribed in the circle; in the same manner may any other polygon, from 4 to 12 sides, be inscribed in a circle, or upon any given line A B.

Ex. 8. *Of Gunter's lines.* We have now shown the use of all that are properly called sectoral lines, or that are to be used sector-wise; but there is another set of lines usually put upon the sector, that will in a more ready and simple manner give the answers to the questions in the above examples, and these are called artificial lines of numbers, sines, and tangents: because they are only the logarithms of the natural numbers, sines, and tangents, laid upon lines of scales, which method was first invented by Mr. Edmund Gunter, and is the reason why they have ever since been called Gunter's lines, or the Gunter.

Logarithms are only the ratios of numbers, and the ratios of all proportional numbers are equal. Now all questions in multiplication, division, the rule of three, and the analogies of plain and spherical trigonometry, are all stated in proportional numbers or terms; therefore, if in the compasses you take the extent (or ratio) between the first and second terms, that will always be equal to the extent (or ratio) between the third and fourth terms; and consequently, if with the extent between the first and second terms, you place one foot of the compasses on the third term, then turning the compasses about, the other foot will fall on the fourth term sought.

Thus in example 1, of the three given numbers 4, 7, and 16, if you take the extent from 4 to 7 in the compasses, and place one foot in 16, the other will fall on 28 the answer, in the lines of numbers marked *n*.

Again, the artificial lines of numbers and sines, are used together in plain trigonometry, as in example 3, where the two angles B and C, and the side AB are given; for here if you take the extent of the two angles 53° 30′ and 36° 30′ in the line of sines marked *s*, then placing one foot upon 230 in the line of numbers *n*, the other will reach to 170, 19 the answer.

Also the lines of numbers and tangents are used conjointly, as in the example 4, for take in the line of tangents *t*, the extent from 45° (radius) to 36° 30′; that will reach from 230 to 170, 19 the answer as before.

Lastly, the artificial lines of sines and tangents are used together in the analogies of spherical triangles.

Thus example 6 is solved by taking in the line of sines *s*, the extent from 90° (radius) to 36° 15′, then that in the line of tangents *t*, will reach from 42° 34′ to 23° 30′, the answer required.

We shall only further observe that each pair of sectoral lines contain the same angle, viz. 6 degrees in the common 6-inch sector; therefore to open these lines to any given angle, as 35° for instance, you have only to take 35° laterally from the line of chords, and apply it parallelwise from 60° to 60° in the same lines, and they will all be opened to the given angle of 35°.

If to the angle 35° you add the angle 6°, which they contain, the sum is 41°: then take 41° laterally from the line of chords, and apply it parallelwise, from 60 to 60, then will the sides or edges of the sector contain the same angle of 35 degrees.

Of proportional compasses. Though this sort of compass does not pertain to a common case of instruments, yet a short account of their nature and use may not be unacceptable to those who are not acquainted with them. They consist of two parts or sides of brass, which lie upon each other, so nicely as to appear but one when they are shut. These sides easily open, and move about a centre, which is itself moveable in a hollow canal cut through the greatest part of their length. To this centre on each side is affixed a sliding piece of a small length, with a fine line drawn on it serving as an index, to be set against other lines or divisions placed upon the compasses on both sides. These lines are: 1. A line of lines. 2. A line of superficies, areas, or plans. 3. A line of solids. 4. A line of circles, or rather of polygons to be inscribed in circles.

These lines are all unequally divided, the three first from 1 to 10, the last from 6 to 20; their uses are as follow:

By the line of lines you divide a given line into any number of equal parts; for by placing the index against 1, and screwing it fast, if you open the compasses, then the distance between the points at each end will be equal. If you place the index against 2, and open the compasses, the distance between the points of the longer legs will be twice the distance between the shorter ones; and thus a line is bisected, or divided into two equal parts. If the index be placed against 3, and the compasses opened, the distances between the points will be as 3 to 1, and so a line is divided into three equal parts; and so you proceed for any other number of parts under 10.

The numbers of the line of plans answer to the squares of those in the line of lines; for because superficies or plans are to each other, as the square of their like sides; therefore if the index be placed against 2 in the line of plans, then the distance between the small points will be the side of a plan whose area is 1; but the distance of the larger points will be the like side of a plan whose area is 2, or twice as big. If the index be placed at 3, and the compasses opened, the distances between the points at each end will be the like sides of plans, whose areas are 1 to 3, and so of others.

The numbers of the line of solids answer to the cubes of those in the line of lines; because all solids are to each other as the cubes of their like sides or diameters; therefore, if the index be placed to No. 2, 3, 4, &c. in the line of solids, the distances between the lesser and larger points will be the like sides of solids, which are to each other as 1 to 2, 1 to 3, 1 to 4, &c. For example, if the index be placed at 10, and the compass be opened, so that the small points may take the diameter of a bullet weighing 1 ounce, then the distance between the larger points will be the diameter of a bullet or globe of 10 ounces, or which is 10 times as big.

Lastly the numbers in the line of circles are the sides of polygons to be inscribed in a given circle, or by which

a circle may be divided into those equal parts from 6 to 20. Thus if the index be placed at 6, the points of the compasses at either end, when opened to the radius of a given circle, will contain the side of a hexagon, or divide the circle into 6 equal parts. If the index be placed against 7, and the compasses opened, so that the larger points may take in the radius of the circle; then the shorter points will divide the circle into 7 equal parts for inscribing a heptagon. Again, placing the index to 8, and opening the compasses, the larger points will contain the radius, and the lesser points divide the circle into 8 equal parts, for inscribing an octagon or square. And thus you proceed for others.

Instruments, *surgical*. A case of pocket instruments for surgeons, which they ought always to carry about with them, contains lancets of different sizes; scissars fit for several uses; forceps, plain and furnished with teeth; incision-knives, straight and crooked; a spatula, probes, needles, &c. See Surgery.

INSURANCE, laws of. Insurance is regarded by the laws as a contract between two or more parties; that on one paying a certain premium he shall be indemnified or insured against certain risks set forth in the policy. This is extremely convenient in commerce, but was made use of as a kind of gambling till the statute 14 Geo. III. c. 48, that no insurance shall be made on lives, or on any other event, wherein the party insured hath no interest; that in all policies the name of such interested party shall be inserted, and nothing more shall be recovered thereon than the amount of the interest of the insured. This, however, does not extend to marine insurances. But as it was a common practice of insuring large sums without having property on board, and which were called wager policies or insurances, interest or no interest, and of ensuring the same goods several times over, it was enacted, that all insurances, interest or no interest, or without further proof of the interest than the policy, or by way of gaming, or without benefit of salvage to the insurer, should be void, except on privateers, or on ships or goods from the Spanish or Portuguese dominions; and that no re-assurance shall be legal, unless the former insurer be insolvent or dead; and that in the East India trade the lender of money on bottomry, or at respondentia, shall alone have a right to be insured for the money lent; and the borrower shall recover no more upon any insurance than the surplus of his bottomry or respondentia bond. No insurance can be made on any illegal voyage.

It is generally stipulated in policies that the insurer shall not be answerable for any partial loss on certain articles, but on others less difficult to be preserved at sea, but liable to partial injuries, shall be liable for any partial loss above five per cent.; and as to all other goods, and the ship and freight, he shall only be liable for such losses above three per cent. But he is liable on all losses, however small, called general average or losses occasioned by the ship stranding; but this loss must be an immediate, not a remote, consequence of the stranding.

The commencement of the risk on the ship varies in most cases, and usually continues till the ship has been 24 hours at safe anchor. Upon goods it commences when they are on board, and continues till they are removed or landed. The ship insured must be sound, and in every respect fit to bear the sea, and perform the voyage; and if she deviates from the usual course, and stops at places not usually stopped at, without a proper cause, the contract is void.

Insurance upon life is a contract by which the insurer, for a certain sum proportioned to the age, health, and profession of the person whose life is to be insured, engages that the person shall not die within a certain period, or if he do, the underwriter will pay a sum of money to the person to whom the policy is granted.

Insurance against fire. The insurer undertakes, in consideration of a premium, to indemnify the insured against all losses by fire which he may sustain in his house or goods during the time mentioned in the policy.

INTAGLIOS, precious stones on which are engraven the heads of great men, inscriptions, and the like; such as we frequently see set in rings, seals, &c.

INTEGER, in arithmetic, a whole number, in contradistinction to a fraction.

INTERCALARY, in chronology. See Bissextile, &c.

INTERCOMMONING, in law, is when the commons of two manors lie together, and the inhabitants of both have, time out of mind, caused their cattle to feed promiscuously on them.

INTERCOSTAL. See Anatomy.

INTERDICT, an ecclesiastical censure, by which the church of Rome forbids the performance of divine service in a kingdom, province, town, &c. This censure has been frequently executed in France, Italy, and Germany; and in the year 1170 pope Alexander III. put all England under an interdict, forbidding the clergy to perform any part of divine service, except baptising of infants, taking confessions, and giving absolution to dying penitents.

INTEREST, a sum of money, paid or allowed for the loan or use of some other sum, lent for a certain time, according to some fixed rate or proportion. The sum lent, and on which the interest is reckoned, is called the principal; and in any case where there is hazard of the loss or diminution of the principal, a proportionately greater interest is usually paid. The current rate of interest is generally considered as the barometer of public credit; and its lowness is a sign almost infallible of the flourishing condition of a state; it proves the increase of industry, and the free circulation of wealth, little inferior to a demonstration. In order to prevent individuals from taking unjust advantages of the necessities of others, it has been found necessary in most countries to establish by law a fixed rate of interest for the use of money: this however must, in a great measure, depend on the current rate of interest in the country; for if it is attempted to reduce by law the common rate of interest below the lowest ordinary market rate, the restriction will be sure to be evaded. This was the case in France in 1766, when, although the legal rate of interest was reduced from five to four per cent, money continued to be lent at five per cent.

The first act of parliament for regulating the interest for money lent in England was 37 Hen. VIII. c. 9. by which interest was fixed at 10 per cent.; before that time interest had usually been taken at higher rates. In 1552 an act was passed against usury, or taking any interest

whatever for money lent: the impolicy and oppression of this measure soon became evident; and in 1571 the statute of Henry VIII. which fixed interest at 10 per cent., was revived. As the increase of commerce brought wealth into the country, the rate of interest lowered; and in 1625 it was, by 21 James I. c. 17, reduced to eight per cent. The first positive law made in Scotland for fixing the rate of interest was in 1587, when an act was passed, by which the rate of interest was not for the future to exceed 10 per cent. In France, in 1601, Henry IV. issued an edict for reducing the public or national interest of money in that kingdom to six and a quarter per cent. In 1651 the interest of money in several parts beyond sea being lower than the legal interest in England, the Rump-parliament reduced the legal rate from eight to six per cent.; and upon the Restoration it was confirmed by 12 Cha. II. c. 13. The last act of parliament for regulating the interest of money was 12 Ann. st. 2. c. 16, by which it was fixed at five per cent. per annum, the present legal rate. But although this is the utmost interest which can be taken for money lent in Great Britain, yet if a contract which carries interest was made in a foreign country, our courts will direct the payment of interest according to the laws of the country in which the contract was made: thus American, Turkish, and Indian interest have been allowed, to the amount of even 12 per cent.

The various rates which have been paid in Great Britain at different periods, as the current interest for money, are as follows:

	Per cent. per ann.		
In 1255 - -	*L.*50	0	0
1263, 2*d.* a-week for 1*l.* or	43	6	8
1270 to 1307 -	45	0	0
1422 to 1470 -	15	0	0
1545 restricted to	10	0	0
1553 to 1558 -	12	0	0
1571 restricted to	10	0	0
1524 to 1604, about	9	16	0
1625 reduced to -	8	0	0
1645 to 1660 -	6	0	0
1660 to 1690 - -	7	6	6
1690 to 1697 - -	7	10	0
1697 to 1706 - -	6	0	0
1714 reduced to -	5	0	0

In the United States of America, the lawful interest of money is 6 per cent. in most of the states; in a few it is 7 per cent.; in one it is 5 per cent. In Greece, the mean rate of interest is 20 per cent, and in the other parts of Turkey nearly the same; in Persia 25 per cent.; and in the Mogul Empire 30 per cent. In these countries there is no fixed rate of interest, and the usual high rate arises chiefly from the insecurity of lending. In Sydney and the other English settlements in New South Wales, the rate of interest is fixed by an ordinance, dated 14th June, 1804, at 8 per cent. per annum.

Interest is disguished into *Simple Interest* and *Compound Interest.*

Interest, *Simple*, is that which is reckoned on the principal only, at a certain rate for a year. and at a proportionately greater or less sum for a greater or less time; thus, if 5*l.* is the rate of interest of 100*l.* for a year, 10*l.* is the interest for two years, 15l. for three years, &c. In most computations of interest the work is much shortened if the interest of 1*l.* for a given term is known, as the interest of any other sum for the same term will then be found by only multiplying by the given sum. The interest of 1*l.* for a year must be in the same proportion as the interest of 100*l.* to its principal; therefore at 5 per cent, as $100 : 5 :: 1 : \frac{5}{100} = ,05$; and thus:—

The interest of One Pound for One Year.

L.	*L.*
at 3 per cent. is -	,03
$3\frac{1}{2}$ - - -	,035
4 - - -	,04
$4\frac{1}{2}$ - - -	,045
5 - - -	,05
$5\frac{1}{2}$ - - -	,055
6 - - -	,06

The interest of One Pound for any number of years.

Years.	3 per Cent.	$3\frac{1}{2}$ per Cent.	4 per Cent.	$4\frac{1}{2}$ per Cent.	5 per Cent.
10	,3	,35	,4	,45	,5
20	,6	,7	,8	,9	1,0
30	,9	1,05	1,2	1,35	1,5
40	1,2	1,4	1,6	1,8	2,0
50	1,5	1,75	2,0	2,25	2,5
60	1,8	2,1	2,4	2,7	3,0
70	2,1	2,45	2,8	3,15	3,5
80	2,4	2,8	3,2	3,6	4,0
90	2,7	3,15	3,6	4,05	4,5
100	3,0	3,5	4,0	4,5	5,0

Although the law forbids any person lending money to take more than 5*l.* for the interest of 100*l.* for a year; yet by allowing the proportionate part of 5*l.* to be taken for part of a year, it permits any one who lends money for a less term than a year, to receive more than he ought if he were to make only five per cent. per annum of his money; for, if he lends 100*l.* for six months, he receives 102*l.* 10*s.*, and this being lent again for the remaining six months, amounts to 105*l* 1*s.* 3*d.*; if the time is less than six months the difference must be still greater. The letter of the law is however the rule in practice, and therefore the 365th part of the yearly interest is always considered as the proper interest for a day, and its multiples as the interest for any number of days.

The Interest of One Pound for One Day,

L.	*L.*
At 3 per cent is - - -	,00008219
$3\frac{1}{2}$ - - - -	,00009589
4 - - - -	,00010959
$4\frac{1}{2}$ - - - -	,00012329
5 - - - -	,00013699
$5\frac{1}{2}$ - - - -	,00015068
6 - - - -	,00016438

As tables of Simple Interest are chiefly referred to, in order to find the interest or discount on bills of exchange, and as by far the greater number of bills which are discounted have less than 100 days to run, the following table will answer most useful purposes; but those who have constant occasion to make such computations,

will derive much assistance from the extensive tables which have been computed by Smart, Thomson, King, Reid, and others. See also DISCOUNT.

TABLE

Showing the Simple Interest of One Pound, for any number of days, not exceeding 100, at 5 per Cent.

days	Amount.	days	Amount.	days	Amount.
1	,0001369	35	,0047945	69	,0094520
2	,0002739	36	,0049315	70	,0095890
3	,0004109	37	,0050684	71	,0097260
4	,0005479	38	,0052054	72	,0098630
5	,0006849	39	,0053424	73	,0100000
6	,0008219	40	,0054794	74	,0101369
7	,0009589	41	,0056164	75	,0102739
8	,0010958	42	,0057534	76	,0104109
9	,0012328	43	,0058904	77	,0105479
10	,0013698	44	,0060274	78	,0106849
11	,0015068	45	.0061643	79	,0108219
12	,0016438	46	,0063013	80	,0109589
13	,0017808	47	,0064383	81	,0110958
14	,0019178	48	,0065753	82	,0112328
15	,0020547	49	.0067123	83	.0113698
16	,0021917	50	,0068493	84	.0115068
17	,0023287	51	,0069863	85	,0116438
18	,0024657	52	,0071232	86	.0117808
19	,0026027	53	,0072602	87	.0119178
20	,0027397	54	,0073972	88	.0120547
21	,0028767	55	,0075342	89	.0121917
22	,0030137	56	,0076712	90	,0123287
23	,0031506	57	,0078082	91	.0124657
24	,0032876	58	,0079452	92	.0126027
25	,0034246	59	,0080821	93	.0127397
26	,0035616	60	,0082191	94	,0128767
27	,0036986	61	,0083561	95	,0130137
28	,0038356	62	,0084931	96	.0131506
29	,0039726	63	,0086301	97	.0132876
30	,0041095	64	,0087671	98	.0134246
31	,0042465	65	,0089041	99	.0135616
32	,0043835	66	,0090411	100	,0136986
33	,0045205	67	,0091780		
34	,0046575	68	,0093150		

The interest of any sum for any number of days contained in the table, is found by only multiplying the figures corresponding with the number of days by the sum: thus, if the interest of 150*l.* for 61 days is required, the interest of one pound for 61 days is, by the table, ,0083561, which multiplied by 150, gives 1*l.* 5*s.* 0$\frac{3}{4}$*d.* If the given sum contains shillings and pence, they must be reduced to the decimal of a pound. The interest for any greater number of days than are contained in the table, is easily found by means of it; thus, if it is required to find the interest of 100*l.* for 165 days, the interest for 100 days by the table is 1,36986, and for 65 days ,89041, which two sums added together, make 2,26027, or 2*l.* 5*s.* 2*d.* But, although it is most convenient in common practice to make use of tables for finding the interest for days, the interest of any sum for any number of days may be correctly and expeditiously obtained without the use of any table, by the following rule:

"Multiply the given sum by the number of days, and divide by 7300."

Example 1. What is the interest of 356*l.* for 112 days?

356 multiplied by 112, and divided by 7300, gives 5,4619, or 5*l.* 9*s.* 2$\frac{3}{4}$*d.*

Example 2. What is the interest of 137*l.* 18*s.* for 97 days?

137,9 multiplied by 97, and divided by 7300, gives 1,8323, or 1*l.* 16*s.* 7$\frac{3}{4}$*d.*

The amount of a given sum in any time may be found by multiplying the Principal, Time, and Rate together; and adding the product to the principal.

Example 1. What sum will 37*l.* 10*s.* amount to in 3 years and 146 days, at 4 per cent. per annum?

37,5 multiplied by 3,4, and the product multiplied by ,04, gives 5,1; which added to 37,5, makes 42,6, or 42*l.* 12*s.*

Example 2. What sum will One Penny amount to in 1816 years, at 5 per cent. per annum?

,004166 multiplied by 1816, and the product multiplied by ,05, gives ,3782728, which, added to the principal, makes ,3824388, or 7*s.* 7$\frac{3}{4}$*d.*

This example sets the difference between simple and compound interest in a most striking point of view; it appears that one penny put out at interest at the birth of Christ, would (at 5 per cent. simple interest) have amounted at the present time to 7*s.* 7$\frac{3}{4}$*d.*, but at compound interest, it would have increased in the same period to a greater sum than would be contained in six hundred millions of globes, each equal to the earth in magnitude, and all solid gold.

INTEREST, *compound*, is that which is reckoned on the principal and its interest put together, as the interest becomes due, so as to form a new capital from each period at which the interest is payable: it is sometimes called interest upon interest. It is not lawful to lend money at compound interest; but in the granting or purchasing of annuities, leases, or reversions, it is usual to allow the purchaser compound interest for his money; and the difference from simple interest is so great, in all cases in which the period of time is considerable, that almost all computations relating to annual payments of money for a number of years, are made at compound interest, unless it is otherwise agreed.

Let $r =$ the amount of 1*l.* in one year, viz. principal and interest.

$n =$ the number of years, in which

$p =$ the principal, increases to

$a =$ the amount:

then $1 : r :: r : r^2$ the amount of 1*l.* in 2 years

$1 : r :: r^2 : r^3$ the amount of 1*l.* in 3 years

$1 : r :: r^3 : r^4$ the amount of 1*l.* in 4 years.

&c.;

threfore r^n, or r raised to the power whose exponent is is the number of years, will be the amount of 1*l.* in those years; and as

1*l.* : $r^n :: p : a$, the amount of a given principal in the same time. Thus,

If Principal, Time, and Rate, are given, to find the Amount?

Theo. 1. $p \times r^n = a$.

If Amount, Time, and Rate, are given, to find the Principal?

Theo. 2. $\frac{a}{r^n} = p.$

If Principal, Amount, and Time, are given, to find the Rate?

Theo. 3. $\sqrt[n]{\frac{a}{p}} = r.$

If Principal, Amount, and Rate, are given, to find the Time?

Theo. 4. $\left\{\begin{array}{l}\frac{a}{p} = r^n, \text{ therefore } \frac{a}{p} \text{ being divided by } r \\ \text{till nothing remains, the number of di-} \\ \text{visions will } = n.\end{array}\right.$

But for greater convenience in practice, these theorems may be expressed in logarithms, as follows:

1. $\log. p + \overline{n \times \log. r} = \log. a.$
2. $\log. a - \overline{n \times \log. r} = \log. p.$
3. $\frac{\log. a - \log. p}{n} = \log. r.$
4. $\frac{\log. a - \log. p}{\log. r} = n.$

On these principles all tables of Compound Interest are formed, of which the following are the most useful.

TABLE I.

Showing the Sum to which 1l. Principal will increase at 5 per Cent. Compound Interest, in any number of years not exceeding a hundred.

Yrs.	Amount.	Yrs.	Amount.	Yrs.	Amount.
1	1.05	35	5.516015	69	28.977548
2	1.1025	36	5.791816	70	30.426425
3	1.157625	37	6.081406	71	31.947746
4	1.215506	38	6.385477	72	33.545134
5	1.276281	39	6.704751	73	35 222300
6	1.340095	40	7.039988	74	36 983510
7	1.407100	41	7.391988	75	38.832685
8	1.477455	42	7.761587	76	40.774320
9	1.551328	43	8 149666	77	42.813036
10	1.628894	44	8.557150	78	44.953688
11	1.710339	45	8 985007	79	47.201372
12	1.795856	46	9.434258	80	49.561441
13	1.885649	47	9.905971	81	52.039513
14	1.979931	48	10.401269	82	54.641488
15	2.078928	49	10.921333	83	57.373563
16	2.182874	50	11.467399	84	60.242241
17	2.292018	51	12.040769	85	63.254353
18	2.406619	52	12.642808	86	66.417071
19	2.526950	53	13.274948	87	69.737924
20	2.653297	54	13.938696	88	73 224820
21	2.785962	55	14 635630	89	76.886061
22	2.925260	56	15.367412	90	80.730365
23	3.071523	57	16.135783	91	84.766883
24	3.225099	58	16.942572	92	89.005227
25	3.386354	59	17 789700	93	93.455488
26	3.555672	60	18.678185	94	98 128263
27	3.733456	61	19.613145	95	03.034676
28	3.920129	62	20.593802	96	108.186410
29	4.116135	63	21.623492	97	113.595730
30	4.321942	64	22.704667	98	119.275517
31	4.538039	65	23.839900	99	125.239293
32	4.764941	66	25.031895	100	131.501257
33	5.003188	67	26.283490		
34	5.253347	68	27.597664		

In order to find what any sum will amount to in a given number of years, it is only necessary to multiply the number in the Table opposite to the term of years by the sum, and the product will be the answer.

Example. To what sum will 50*l.* increase in 69 years, at 5 per cent. compound interest?

The number in the table corresponding with 69 years is 28.977548, which multiplied by 50, gives 1448.8774, or 1448*l.* 17*s.* 6*d.*

The number of years in which a given sum will increase to another given sum in consequence of being improved at interest, is found by dividing the latter sum by the former, and the sum in the table which is nearest to the quotient will show the term required.

Example. In what time will 100*l.* increase to 500*l.*, if improved at 5 per cent?

Divide 500 by 100, and the number in the table nearest to 5 the quotient, is 5.003188, which shows that 33 years is the answer.

TABLE II.

Showing the present Value of 1l. to be received at the end of any number of years, not exceeding 100; discounting at 5 per Cent. Compound Interest.

Yrs.	Value.	Yrs.	Value.	Yrs.	Value.
1	.952381	35	.181290	69	.034509
2	.907029	36	.172657	70	.032866
3	.863838	37	.164436	71	.031301
4	.822702	38	.156605	72	.029811
5	.783526	39	.149148	73	.028391
6	.746215	40	.142046	74	.027039
7	.710681	41	.135282	75	.025752
8	.676839	42	.128840	76	.024525
9	.644609	43	.122704	77	.023357
10	.613913	44	.116861	78	.022245
11	.584679	45	.111297	79	.021186
12	.556837	46	.105997	80	.020177
13	.530321	47	.100949	81	.019216
14	.505068	48	.096142	82	.018301
15	.481017	49	.091564	83	.017430
16	.458112	50	.087204	84	.016600
17	.436297	51	.083051	85	.015809
18	.415521	52	.079096	86	.015056
19	.395734	53	.075330	87	.014339
20	.376889	54	.075743	88	.013657
21	.358942	55	.068326	89	.013006
22	.341850	56	.065073	90	.012387
23	.325571	57	.061974	91	.011797
24	.310068	58	.059023	92	.011235
25	.295303	59	.056212	93	.010700
26	.281241	60	.053536	94	.010191
27	.267848	61	.050986	95	.009705
28	.255094	62	.048558	96	.009243
29	.212946	63	.046246	97	.008803
30	.231377	64	.044044	98	.008384
31	.220359	65	.041946	99	.007985
32	.209866	66	.039949	100	.007604
33	.199873	67	.038047		
34	.190355	68	.036235		

In order to find the present worth of any sum which is to be received at the end of a certain number of years, multiply the number in the table opposite to the term of years, by the sum, and this product will be the answer.

Example. What is the present value of 500*l.* to be received at the expiration of 14 years?

The number in the table corresponding with 14 years, is .505068, which multiplied by 500, gives 252,534, or 252*l.* 10*s.* 8*d.*

For the present value or amount of annual payments, as Annuities, Pensions, Leases, &c. at Compound Interest, see ANNUITIES.

INTEREST, in law, is generally taken for a chattel real, or a lease for years, &c. but more for a future term.

An estate in lands, &c. is better than a bare interest therein; yet, according to the legal sense of the word, an interest extends to estates and titles which a person has in or out of lands, &c.; for by grant of a person's whole interest in land, a reversion, as well as possession, in fee-simple, passes.

INTERJECTION, in grammar, an indeclinable part of speech, signifying some passion or emotion of the mind.

INTERLOCUTORY ORDER, in law, an order that does not decide the cause, but only some matter incident to it, which happens between the beginning and end of a cause; as when, in chancery or exchequer, the plaintiff obtains an order for an injunction until the hearing of the cause; which order, not being final, is called interlocutory.

INTERMITTENT, or INTERMITTING FEVERS. See MEDICINE.

INTERNAL, in general, signifies whatever is within a thing.

Euclid proves that the sum of the three internal angles of every triangle is equal to two right angles; whence he deduces several useful corollaries. He likewise adduces, from the same proposition, this theorem, viz. that the sum of the angles of every rectilinear figure, is equal to twice as many right angles, as the figure hath sides, excepting or subtracting four.

INTERROGATORIES, are questions exhibited in writing to be asked witnesses or contemnors to be examined. Those interrogatories are in the nature of a charge or accusation; and if any of them is improper, the defendant may refuse to answer it, and move the court to have it struck out. Str. 444.

INTERSECTION, in the mathematics, signifies the cutting of one line or plane by another: thus we say, that the mutual intersection of two planes is a right line.

INTERVAL, in music, the difference in point of gravity or acuteness between any two sounds. Taking the word in its more general sense, we must allow that the possible intervals of sound are infinite, but we only speak of those intervals which exist between the different tones of any established system. The ancients divided the intervals into simple, or uncomposite, which they call diastems, and composite intervals, which they call systems. The least of all the intervals in the Greek music was, according to Bacchius, the enharmonic diesis, or fourth of a tone; but our scale does not notice so small a division, since all our tones concur in consonances, to which order only one of the three ancient genera, viz. the diatonic, was accommodated. Modern musicians consider the semitone as a simple interval, and only call those composite which consist of two or more semitones: thus from B to C is a semitone, or simple interval, but from C to D is two half-tones, or a compound interval.

INTESTATES. There are two kinds of intestates; one that makes no will at all; and another that makes a will, and nominates executors, but they refuse; in which case he dies an intestate, and the ordinary commits administration. 2 Par. Inst. 397.

The ordinary by special acts of parliament is required to grant administration of the effects of the deceased to the widow or next of kin, who shall first pay the debts of the deceased, and then distribute the surplus among the kindred, in the manner and according to the proportions directed by 22 and 23 Car. II. c. 10.

INTESTINA, in natural history, an order of vermes. The individuals of this order are of a formation the most simple, and live some of them within other animals, some in waters, and a few in the earth. The gordius perforates clay to give a passage to springs and water; the lumbricus pierces the earth, that it may be exposed to the action of the air and moisture: in like manner the teredo penetrates wood; and the phloas and mytillus rocks, to effect their dissolution.

INTESTINES. See ANATOMY, and PHYSIOLOGY.

INTRUSION, in law, is when the ancestor diesse ised of any estate of inheritance, expectant upon an estate for life; and then the tenant for life dies, between whose death, and the entry of the heir, a stranger intrudes.

INVECTED, in heraldry, denotes a thing fluted or furrowed. See HERALDRY.

INVENTION. See PAINTING.

INVESTITURE, in law, is the giving possession of lands by actual seisin. The ancient feudal investiture was, where the vassal on descent of land was admitted into the lord's court, and there received his seisin, in the nature of a renewal of his ancestor's grant, in the presence of the rest of the tenants: but in aftertimes, entering on any part of the lands, or other notorious possession, was admitted to be equivalent to the formal grant of seisin and investiture. 2 Black. 209.

The manner of grant was by words of pure donation, "have given and granted:" which are still the operative words in our modern infeodations or deeds of feoffment. This was perfected by the ceremony of corporal investiture, or open and notorious delivery of possession in the presence of the other vassals.

But a corporeal investiture being sometimes inconvenient, a symbolical delivery of possession was in many cases anciently allowed of; by transferring something near at hand, in the presence of credible witnesses, which by agreement should serve to represent the very thing designed to be conveyed; and an occupancy of this sign or symbol was permitted as equivalent to the occupancy of the land itself. And to this day, the conveyance of many of our copyhold estates is made from the seller to the lord, or his steward, by delivering a rod or verge, and then from the lord to the purchaser, by a re-delivery of the same, in the presence of a jury of tenants. 2 Black. 313.

INULA, fleabane, a genus of the syngenesia polygamia-superflua class of plants, with radiated flowers: the receptacle is naked; the down is simple; and the antheræ terminate in setæ at their bases. There are thirty-four species, of no note.

INVOICE, an account in writing of the particulars of merchandise, with their value, custom, charges, &c. transmitted by one merchant to another in a distant country.

One copy of every invoice is to be inserted verbatim in the invoice-book, for the merchant's private use; and another copy must, immediately upon shipping off the goods, be despatched by post, or otherwise, to the correspondent. This copy is commonly drawn out upon a sheet of large post-paper, to the end of which is subjoined a letter of advice.

INVOLUCRUM. See BOTANY.

INVOLUTION. See ALGEBRA.

IONIC ORDER. See ARCHITECTURE.

IPECACUANHA. See MATERIA MEDICA.

IPOMEA, *quamoclit*, or scarlet convolvulus, a genus of the monogynia order, in the pentandria class of plants; and in the natural method ranking under the 29th order, campanaceæ. The corolla is funnel-shaped; the stigma round-headed; the capsule trilocular. There are twenty-seven species; but not more than one (the coccinea) cultivated in our gardens. This has long, slender, twining stalks, rising upon support six or seven feet high, from the sides of which arise many slender footstalks, each supporting several large and beautiful funnel-shaped and scarlet flowers. There is a variety with orange-coloured flowers. Both of them are annual.

IRELAND. By statutes 39 and 40 Geo. III. c. 67. the kingdoms of Great Britain and Ireland shall, upon the first day of Jan. 1801, and for ever after, be united, by the name of the United Kingdom of Great Britain and Ireland; and the royal style and titles appertaining to the imperial crown of the said united kingdom and its dependancies, and also the ensigns armorial, flags and banners thereof, shall be such as his majesty, by his royal proclamation under the great seal of the united kingdom, shall be pleased to appoint.

Where a debt is contracted in England, and a bond is taken for it in Ireland, it shall carry Irish interest; for it must be considered as referable to the place where it is made: but if it was a simple-contract debt only, it ought to carry English interest, the variation of place in this case making no difference. 2 Atk. 382.

IRESINE, a genus of the pentandria order, in the diœcia class of plants; and in the natural method ranking under the 54th order, miscellaneæ. The male calyx is diphyllous, the corolla pentapetalous, and there are five nectaria. The female calyx is dyphyllous, the corolla pentapetalous; there are two sessile stigmata, and a capsule with flocky seeds. There is one species, a herb of Jamaica.

IRIDIUM, a new metal lately discovered by Mr. Tennant in the ore of platina. It is of a white colour, and perfectly infusible. It does not combine with sulphur or arsenic. Lead unites with it, but may be separated by cupellation. Copper, silver, and gold, are found to combine with it.

IRIS, the flower-de-luce, or flag-flower, &c.; a genus of the monogynia order in the triandria class of plants; and in the natural method ranking under the sixth order, ensatæ. The corolla is divided into six parts; the petals alternately reflexed; the stigmata resembling petals.

There are fifty species, all herbaceous flowering perennials, both of the fibrous, tuberous, and bulbous-rooted kind, producing thick annual stalks from three or four inches to a yard high, terminated by large hexapetalous flowers, having three of the petals reflexed quite back, and three erect; most of which are very ornamental, appearing in May, June, and July. All the species are easily propagated by offsets from the roots, which should be planted in September. October, or November, though almost any time from September to March will do. They may also be raised from seed, which is the best method for procuring varieties. It is to be sown in autumn, soon after it ripens, in a bed or border of common earth, and raked in. The plants will rise in the spring, and are to be transplanted next autumn.

IRON, the most abundant, and the most useful of all metals, was neither known so early, nor wrought so easily as gold, silver, and copper.

Iron is of a blueish white colour; and when polished, has a great deal of brilliancy. It has a styptic taste, and emits a smell when rubbed. Its specific gravity varies from 7.6 to 7.8. It is attracted by the magnet or loadstone, and is itself the substance which constitutes the loadstone. But when iron is perfectly pure, it retains the magnetic virtue a very short time. It is malleable in every temperature, and its malleability increases in proportion as the temperature augments; but it cannot be hammered out nearly so thin as gold or silver, or even copper. Its ductility, however, is more perfect; for it may be drawn out into wire as fine at least as human hair. Its tenacity is such, that an iron wire 0.078 of an inch in diameter is capable of supporting 549,25 lbs. avoirdupois without breaking. When heated to about 158° Wedgewood, it melts. This temperature being nearly the highest to which it can be raised, it has been impossible to ascertain the point at which this melted metal begins to boil and to evaporate. Neither has the form of its crystals been examined: but it is well known that the texture of iron is fibrous; that is, it appears when broken to be composed of a number of fibres or strings bundled together.

When exposed to the air, its surface is soon tarnished, and it is gradually changed into a brown or yellow powder, well known under the name of rust. This change takes place more rapidly if the atmosphere is moist. It is occasioned by the gradual combination of the iron with the oxygen of the atmosphere, for which it has a very strong affinity.

When iron filings are kept in water, provided the temperature is not under 70°, they are gradually converted in a black powder, while a quantity of hydrogen gas is emitted. This is occasioned by the slow decomposition of the water. The iron combines with its oxygen, while the hydrogen makes its escape under the form of gas.

If the steam of water is made to pass through a red-hot iron tube, it is decomposed instantly. The oxygen combines with the iron, and the hydrogen gas passes through the tube, and may be collected in proper vessels. This is one of the easiest methods of procuring pure hydrogen gas.

These facts are sufficient to show that iron has a strong affinity for oxygen, since it is capable of taking it from air and water. It is capable also of taking fire and burning with great rapidity. Twist a small iron wire into the form of a cork-screw, by rolling it round a cylin-

der; fix one end of it into a cork, and attach to the other a small bit of cotton thread dipt in melted tallow. Set fire to the cotton, and plunge it while burning into a jar filled with oxygen gas. The wire catches fire from the cotton, and burns with great brilliancy, emitting very vivid sparks in all directions. For this very splendid experiment we are indebted to Dr. Ingenhousz. During this combustion the iron combines with oxygen, and is converted into an oxide. Mr. Proust has proved that there are only two oxides of iron; and the protoxide has usually a black colour, but the peroxide is red.

The protoxide of iron may be obtained by four different processes. 1. By keeping iron filings a sufficient time in water at the temperature of 70°. The oxide thus formed is a black powder, formerly much used in medicine under the name of martial ethiops, and seems to have been first examined by Lemeri; but a better process is that of De Roover. He exposes a paste formed of iron filings and water to the open air, in a stone-ware vessel; the paste becomes hot, and the water disappears. It is then moistened again, and the process repeated till the whole is oxydized. The mass is then pounded, and the powder is heated in an iron vessel till it is perfectly dry, stirring it constantly. 2. By making steam pass through a red-hot iron tube, the iron is changed into a brilliant black brittle substance, which, when pounded, assumes the appearance of martial ethiops. This experiment was first made by Lavoisier. 3. By burning iron wire in oxygen gas. The wire as it burns is melted, and falls in drops to the bottom of the vessel, which ought to be covered with water, and to be of copper. These metallic drops are brittle, very hard, and blackish, but retain the metallic lustre. They were examined by Lavoisier, and found precisely the same with martial ethiops. They owe their lustre to the fusion which they underwent. By dissolving iron in sulphuric acid, and pouring potass into the solution. 4. A green powder falls to the bottom, which assumes the appearance of martial ethiops when dried quickly in close vessels. This first oxide of iron, however formed, is always composed of 73 parts of iron and 27 of oxygen, as Lavoisier and Proust have demonstrated. It is attracted by the magnet, and is often itself magnetic. It is capable of crystallizing, and is often found native in that state.

The peroxide or red oxide of iron may be formed by keeping iron filings red-hot in an open vessel, and agitating them constantly till they are converted into a dark red powder. This oxide was formerly called saffron of Mars. Common rust of iron is merely this oxide combined with carbonic acid gas. The red oxide may be obtained also by exposing for a long time a diluted solution of iron in sulphuric acid to the atmosphere, and then dropping into it an alkali, by which the oxide is precipitated. This oxide is also found native in great abundance. Proust proved it to be composed of 48 parts of oxygen and 52 of iron. Consequently the protoxide, when converted into red oxide, absorbs 0.40 of oxygen; or, which is the same thing, the red oxide is composed of 66.5 parts of black oxide and 33.5 parts of oxygen. One hundred parts of iron, when converted into a protoxide, absorb 37 parts of oxygen, and the oxide weighs 137; when converted into peroxide, it absorbs 52 additional parts of oxygen, and the oxide weighs 189.

The peroxide cannot be decomposed by heat; but when heated along with its own weight of iron filings, the whole, as Vauquelin first observed, is converted into black oxide. The reason of this conversion is evident: This 100 parts of peroxide are composed of 52 parts of iron, combined with two different doses of oxygen: 1. With 14 parts, which, with the iron, make 66 of protoxide: 2. With 34 parts, which, with the protoxide, make up the 100 parts of peroxide. Now, the first of these doses has a much greater affinity for the iron than the second has. Consequently the 34 parts of oxygen, which constitute the second dose, being retained by a weak affinity, are easily abstracted by the 100 parts of pure iron; and combining with the iron, the whole almost is converted into black oxide: for 100 parts of iron, to be converted into black oxide, require only 37 parts of oxygen.

The peroxide of iron is not magnetic. It is converted into black oxide by sulphureted hydrogen gas and many other substances; which deprive it of the second dose of oxygen, for which they have a stronger affinity, though they are incapable of decomposing the protoxide. Iron is capable of combining with all the simple combustible bodies.

A small mixture of it constitutes that particular kind of iron, known by the name of cold short iron, because it is brittle when cold, though it is malleable when hot.

Rinman has shown that the brittleness and bad qualities of cold short iron may be removed by heating it strongly with limestone, and with this the experiments of Levavasseur correspond.

There are a great many varieties of iron, which artists distinguish by particular names; but all of them may be reduced under one or other of the three following classes: cast iron; wrought or soft iron; and steel.

Cast iron, or pig iron, is the name of the metal when first extracted from its ores. The ores from which iron is usually obtained are composed of oxide of iron and clay. The object of the manufacturer is to reduce the oxide to the metallic state, and to separate all the clay with which it is combined. These two objects are accomplished at once, by mixing the ore reduced to small pieces with a certain portion of limestone and of charcoal, and subjecting the whole to a very violent heat in furnaces constructed for the purpose. The charcoal absorbs the oxygen of the oxide, flies off in the state of carbonic acid gas, and leaves the iron in the metallic state; the lime combines with the clay, and both together run into fusion, and form a kind of fluid glass; the iron is also melted by the violence of the heat, and being heavier than the glass, falls down, and is collected at the bottom of the furnace. Thus the contents of the furnace are separated into two portions; the glass swims at the surface, and the iron rests at the bottom. A hole at the lower part of the furnace is now opened, and the iron allowed to flow out into moulds prepared for its reception.

The cast iron thus obtained is distinguished by the following properties: It is scarcely malleable at any temperature. It is generally so hard as to resist the file. It can neither be hardened nor softened by ignition and cooling. It is exceeding brittle. It melts at 130° Wedgewood. It is more sonorous than steel. For the most part it is of a dark-grey or blackish colour; but sometimes it

is whitish, and then it contains a quantity of phosphuret of iron, which considerably impairs its qualities. A great number of utentials are formed of iron in this state.

To convert it into wrought iron, it is put into a furnace, and kept melted, by means of the flame of the combustibles, which is made to play upon its surface. While melted, it is constantly stirred by a workman, that every part of it may be exposed to the air. In about an hour the hottest part of the mass begins to heave and swell, and to emit a lambent blue flame. This continues nearly an hour; and by that time the conversion is completed. The heaving is evidently produced by the emission of an elastic fluid. As the process advances, the iron gradually acquires more consistency; and at last, notwithstanding the continuance of the heat, it congeals all together. It is then taken while hot, and hammered violently, by means of a heavy hammer driven by machinery. This not only makes the particles of iron approach nearer each other, but drives away several impurities which would otherwise continue attached to the iron.

In this state it is the substance described under the name of iron. As it has never yet been decomposed, it is considered at present, when pure, as a simple body; but it has seldom or never been found without some small mixture of foreign substances. These substances are either some of the other metals, or oxygen, carbon, or phosphorus.

When small pieces of iron are stratified in a close crucible, with a sufficient quantity of charcoal-powder, and kept in a strong red heat for eight or ten hours, they are converted into steel, which is distinguished from iron by the following properties.

It is so hard as to be unmalleable while cold, or at least it acquires this property by being immersed while ignited into a cold liquid: for this immersion, though it has no effect upon iron, adds greatly to the hardness of steel.

It is brittle, resists the file, cuts glass, affords sparks with flint, and retains the magnetic virtue for any length of time. It loses this hardness by being ignited and cooled very slowly. It melts at above 130° Wedgewood. It is malleable when red-hot, but scarcely so when raised to a white heat. It may be hammered out into much thinner plates than iron. It is more sonorous; and its specific gravity, when hammered, is greater than that of iron.

By being repeatedly ignited in an open vessel, and hammered, it becomes wrought iron, which is a simple substance, and if perfectly pure would contain nothing but iron.

Steel is iron combined with a small portion of carbon, and has been for that reason called carbureted iron. The proportion of carbon has not been ascertained with much precision. From the analysis of Vauquelin, it amounts, at an average, to $\frac{1}{140}$ part. Mr. Clouet seems to affirm that it amounts to $\frac{1}{32}$ part; but he has not published the experiments which led him to a proportion, which so far exceeds what has been obtained by other chemists.

That steel is composed of iron combined with pure carbon, and not with charcoal, has been demonstrated by Morveau, who formed steel by combining together directly iron and diamond. At the suggestion of Clouet, he inclosed a diamond in a small crucible of pure iron, and exposed it completely covered up in a common crucible to a sufficient heat.

The diamond disappeared, and the iron was converted into steel. The diamond weighed 907 parts, the iron 57800, and the steel obtained 56384; so that 2313 parts of the iron had been lost in the operation. From this experiment it follows, that steel contains about $\frac{1}{60}$ of its weight of carbon. This experiment was objected to by Mr. Mushet, but the objections were fully refuted by sir George M'Kenzie.

Rinman, long ago, pointed out a method by which steel may be distinguished from iron. When a little diluted nitric acid dropt upon a plate of steel, allowed to remain a few minutes, and then washed off, it leaves behind it a black spot; whereas the spot formed by nitric acid on iron is whitish-green. We can easily see the reason of the black spot: it is owing to the carbon of the iron which is converted into charcoal by the acid. This experiment shows us, that carbon is much more readily oxidated when combined with iron than when crystallized in the diamond.

Cast iron, is iron combined with a still greater proportion of carbon than is necessary for forming steel. The quantity has not yet been ascertained with precision: Mr. Clouet makes it amount to $\frac{1}{8}$ of the iron. The blackness of the colour, and the fusibility of cast iron, are proportional to the quantity of carbon which it contains. Cast iron is almost always contaminated with foreign ingredients: these are chiefly oxide of iron, phosphuret of iron, and silica.

It is easy to see why iron is obtained from its ore in the state of cast iron. The quantity of charcoal, along with which the ore is fused, is so great, that the iron has an opportunity of saturating itself with it.

The conversion of cast iron into wrought iron is effected by burning away the charcoal, and depriving the iron wholly of oxygen: this is accomplished by heating it violently while exposed to the air. Mr. Clouet has found, that when cast iron is mixed with $\frac{1}{4}$ of its weight of black oxide of iron, and heated violently, it is equally converted into pure iron. The oxygen of the oxide, and the carbon of the cast iron, combine, and leave the iron in a state of purity.

The conversion of iron into steel is effected by combining it with carbon. This combination is performed in the large way by three different processes, and the products are distinguished by the names of natural steel, steel of cementation, and cast steel.

Natural steel is obtained from the ore by converting it first into cast iron, and then exposing the cast iron to a violent heat in a furnace while its surface is covered with a mass of melted scoriæ five or six inches deep. Part of the carbon combines with the oxygen which cast iron always contains, and flies off in the state of carbonic acid gas. The remainder combines with the pure iron, and constitute it steel. This steel is inferior to the other species; its quality is not the same throughout; it is softer, and not so apt to break; and as the processes by which it is obtained are less expensive, it is sold at a lower price than the other species.

It is obvious that iron and carbon are capable of combining together in a variety of different proportions. When the carbon exceeds, the compound is carburet of

iron, or plumbago. When the iron exceeds, the compound is steel or cast iron in various states, according to the proportion. All these compounds may be considered as subcarburets of iron. The hardness of iron increases with the proportion of charcoal with which it combines, till the carbon amounts to about $\frac{1}{60}$ of the whole mass. The hardness is then a maximum; the metal acquires the colour of silver, loses its granulated appearance, and assumes a crystallized form. If more carbon is added to the compound, the hardness diminishes in proportion to its quantity.

The affinities of iron, and its oxides, are arranged by Bergman as in the following table:

Iron.	Oxide of Iron.
Nickel,	Oxalic acid,
Cobalt,	Tartaric,
Manganese,	Camphoric,
Arsenic,	Sulphuric,
Copper,	Saclatic,
Gold,	Muriatic,
Silver,	Nitric,
Tin,	Phosphoric,
Antimony,	Arsenic,
Platinum,	Fluoric,
Bismuth,	Succinic,
Lead,	Citric,
Mercury,	Lactic,
	Acetic,
	Boracic,
	Prussic,
	Carbonic.

Iron-sick, in the sea-language, is said of a ship or boat, when her bolts or nails are so eaten with rust, and so worn away, that they occasion hollows in the planks, whereby the vessel is rendered leaky.

IRRATIONAL, an appellation given to surd numbers and quantities. See Algebra.

IRREGULAR, in grammar, such inflections of words as vary from the general rules; thus we say, irregular nouns, irregular verbs.

ISATIS, woad; a genus of the siliquosa order, in the tetradynamia class of plants; and in the natural method ranking under the 39th order, the siliquosa. The siliqua is lanceolated, unilocular, monospermous, bivalved, and deciduous; the valves navicular or canoe-shaped. There are four species; but the only one worthy of notice in the tinctoria, or common woad, which is cultivated in several parts of Britain for the purposes of dyeing, being used as a foundation for many of the dark colours. See Dyeing.

ISCHÆMUM, a genus of the monœcia order, in the polygamia class of plants; and in the natural method ranking under the 4th order, gramina. The calyx of the hermaphrodite is a biflorous glume; the corolla bivalved; there are three stamina, two styles, and one seed. The calyx and corolla of the male, as in the former, with three stamina. There are eight species.

ISCHURY. See Medicine.

ISERTIA, a genus of the hexandria monogynia class and order; the cal. is coloured, four or six toothed; cor. six-cleft, funnel-form; pome subglobular, six-celled. There is one species, a tree of Cayenne.

ISINGLASS, in the materia medica, &c. See Accipenser.

ISNARDIA, a genus of the monogynia order, in the tetrandria class of plants; and in the natural method ranking under the 17th order, calycanthemæ. There is no corolla; the calyx is quadrifid; the capsule quadrilocular, and girt with the calyx. There is one species, an aquatic and annual.

ISOCELES Triangle, in geometry, one that has two equal sides.

ISOCHRONAL, Isochrone, or Isochronous, is applied to such vibrations of a pendulum, as are performed in the same space of time; as all the vibrations or swings of the same pendulum are, whether the arches it describes are longer or shorter: for when it describes a shorter arch, it moves so much the slower, and when a long one proportionably faster.

Isochronal line, that in which a heavy body is supposed to descend without any acceleration.

ISOETES, a genus of the natural order of filices, belonging to the cryptogamia class of plants. The antheræ of the male flower are within the base of the frons or leaf. The capsule of the female flower is bilocular, and within the base of the leaf. There are two species.

ISOPERIMETRICAL Figures, in geometry, are such as have equal perimeters, or circumferences.

1. Of isoperimetrical figures, that is the greatest that contains the greatest number of sides, or the most angles, and consequently a circle is the greatest of all figures that have the same perimeter as it has.

2. Of two isoperimetrical triangles, having the same base, whereof two sides of one are equal, and of the other unequal, that is the greater whose two sides are equal.

3. Of isoperimetrical figures, whose sides are equal in number, that is the greatest which is equilateral and equiangular. From hence follows that common problem of making the hedging or walling that will wall in one acre, or even any determinate number of acres a, fence or wall in any greater number of acres whatever b. In order to the solution of this problem, let the greater number b be supposed a square. Let x be one side of an oblong, whose area is a; then will $\frac{a}{x}$ be the other side; and $2\frac{a}{x} + 2x$ will be the perimeter of the oblong, which must be equal to four times the square-root of b; that is, $2\frac{a}{2} + 2x = 4\sqrt{b}$. Whence the value of x may be easily had, and you may make infinite numbers of squares and oblongs that have the same perimeter, and yet shall have different given areas, thus

Let $\sqrt{b} = d$,

$$\text{Then, } \frac{2a + 4xx}{x} = 4d$$

$$a + 2xx = 2dx$$

$$2xx - 2dx = -a$$

$$xx - dx = -\frac{a}{2}$$

$$xx - dx + \tfrac{1}{4}dd = -\frac{a}{2} + \tfrac{1}{4}dd$$

$$x = \sqrt{-\frac{a}{2} + \tfrac{1}{4}dd} + \tfrac{1}{2}d.$$

Thus, if one side of the square be 10; and one side of an oblong be 19, and the other 1: then will the perimeters of that square and oblong be equal, viz. each 40, and yet the area of the square will be 100, and of the oblong but 19.

ISOPYRUM, in botany, a genus of the polygynia order, in the polyandria class of plants; and in the natural method ranking under the 26th order, multisiliquæ. There is no calyx, but five petals; the nectaria trifid and tubular; the capsules recurved and polyspermous. There are two species, of no note.

ISSUE, in law, has several significations, it being sometimes taken for the children begotten between a man and his wife; sometimes for profits arising from amercements and fines; and sometimes for the profits issuing out of lands or tenements: but this word generally signifies the conclusion, or point of matter, that issues from the allegations and pleas of the plaintiff and defendant in a cause to be tried by a jury or court.

There are two kinds of issues in relation to causes, that upon a matter of fact, and that upon a matter of law: that of fact is where the plaintiff and defendant have fixed upon a point to be tried by a jury: and that in law is where there are a demurrer to a declaration, &c. and a joinder in demurrer, which is determinable only by the judges. Issues of fact are either general or special: they are general, when it is left to the jury to find whether the defendant has done any such thing as the plaintiff has alleged against him; and special, where some special matter, or material point alleged by the defendant in his defence, is to be tried. General issue also signifies a plea in which the defendant is allowed to give the special matter in evidence, by way of excuse or justification; this is granted by several statutes, in order to prevent a prolixity in pleading, by allowing the defendant to give any thing in evidence, to prove that the plaintiff had no cause for his action.

Issues *on sheriffs*, are such amercements and fines to the crown, as are levied out of the issues and profits of the lands of sheriffs, for their faults and neglects: but these issues, on showing a good and sufficient cause, may be taken off before they are estreated into the exchequer.

Issues. See Surgery.

ITEA, a genus of the monogynia order, in the pentandria class of plants; and in the natural method ranking with those of which the order is doubtful. The petals are long, and inserted into the calyx; the capsule unilocular and bivalved. There are two species, natives of North America.

IVA, a genus of the pentandria order, in the monœcia class of plants; and in the natural method ranking under the 49th order, compositæ. The male calyx is common and triphyllous; the florets of the disc monopetalous and quinquefid; the receptacle divided by small hairs. There is no female calyx nor corolla; but five florets in the radius; two long styles; and one naked and obtuse seed. There are two species, natives of America.

IVORY, ebur, in natural history, &c. a hard, solid, and firm substance, of a white colour, and capable of a very good polish. It is the tusk of the elephant, and is hollow from the base to a certain height, the cavity being filled up with a compact medullary substance, seeming to have a great number of glands in it. It is observed that the Ceylon ivory, and that of the island of Achem, do not become yellow in the wearing, as all other ivory does; for this reason the teeth of these places bear a larger price than those of the coast of Guinea.

To soften ivory and other bones, lay them for twelve hours in aqua fortis, and then three days in the juice of beets, and they will become so soft that they may be worked into any form. To harden them again, lay them in strong vinegar. Dioscorides says, that by boiling ivory for the space of six hours with the root of mandragoras, it will become so soft that it may be managed as one pleases.

Ivory-*black* is the coal of ivory or bone formed by great heat, while deprived of all access of air.

IVY. See Hedera.

IXIA, a genus of the monogynia order, in the triandria class of plants; and in the natural method ranking under the sixth order, ensatæ. The corolla is hexapetalous, patent, and equal; there are three stigmata, a little upright and petalous. There are fifty-four species, consisting of herbaceous, tuberous, and bulbous-rooted flowery perennials, from one to two feet high, terminated by hexapetalous flowers of different colours. They are propagated by offsets, which should be taken off in summer at the decay of the leaves: but as all the plants of this genus are natives of warm climates, few of them can bear the open air of this country in winter.

IXORA, a genus of the tetrandria monogynia class of plants. The corolla consists of a single petal; the tube is cylindric, very long and slender; the limb is plane, and divided into four oval segments; the fruit is a berry of a roundish figure, with only one cell; the seeds are four in number, convex on one side, and angular on the other. There are nine species, very ornamental shrubs for the stove.

J.

JACK, in mechanics, an instrument in common use for raising heavy timber, or very great weights of any kind, being a powerful combination of teeth and pinions, and the whole inclosed in a strong wooden stock or frame BC, and moved by a winch or handle HP; the outside appearing as in Plate LXXII. Miscel. fig. 131. In fig. 132, the wheel or rack work is shown, being the view of the inside when the stock is removed. Though it is not drawn in the just proportions and dimensions, for the rack AB must be supposed at least four times as long in proportion to the wheel Q, as the figure represents it; and the teeth, which will be then four times more in number, to have about three in the inch. Now if the handle HP is seven inches long, the circumference

of this radius will be 44 inches, which is the distance or space the power moves through in one revolution of the handle; but as the pinion of the handle has but four leaves, and the wheel Q suppose 20 teeth, or five times the number, therefore to make one revolution of the wheel Q, it requires five turns of the handle, in which case it passes through 5 times 44 or 220 inches; but the wheel having a pinion R of three leaves, these will raise the rack three teeth, or one inch, in the same space. Hence, then, the handle or power moving 220 times as fast as the weight, will raise or balance a weight of 220 times its own energy. And if this is the hand of a man who can sustain 50 pounds weight, he will, by the help of this jack, be able to raise or sustain a weight or force of 11000 pounds, or about five tons weight.

This machine is sometimes open behind from the bottom almost up to the wheel Q, to let the lower claw, which in that case is turned up as at B, draw up any weight. When the weight is drawn or pushed sufficiently high, it is kept from going back by hanging the end of the hook S, fixed to a staple, over the curved part of the handle at *h*.

The Society of Arts rewarded Mr. Mocock of Southwark, with a premium of 20 guineas, for his contrivance to prevent a jack from taking a retrogade course whenever the weight by any accidental circumstance overbalances the power. The improved jack only differs from those in common use in this respect, that it has a pall or clock, and ratchet, applied in such manner as to stop the motion of the machine as soon as it begins to run back again. As the difference in the mechanism is very trifling, the improvement may be easily applied to any common jacks already made.

Jack is also the name of a well-known engine in the kitchen, used for turning a spit. Here the weight is the power applied, acting by a set of pulleys; the friction of the parts, and the weight with which the spit is charged, are the forces to be overcome; and a steady uniform motion is maintained by means of a fly.

The common worm-jack is represented at Plate LXXII. Miscel. fig. 130. ABC is the barrel round which the cord QR is wound; KL the main wheel, commonly containing 60 teeth; N the worm-wheel of about thirty teeth, cut obliquely; LM the pinion, of about 15; O the worm or endless screw, consisting of two spiral threads, making an angle of sixty or seventy degrees with its axis; X the stud, and Z the loop of the worm-spindle; P a heavy wheel or fly, connected with the spindle of the endless screw to make the motion uniform; DG the struck wheel fixed to the axis FD; S,S,S, are holes in the frame, by which it may be nailed to a board, and thence to any wall, the end D being permitted to pass through it; HI the handle going upon the axis ET, to wind up the weight when it has run down. R is a box of fixed pulleys, and V a corresponding one of moveable pulleys carrying the weight. The axis ET is fixed in the barrel AC, which axis being hollow, both it and the barrel turn round upon the axis FD, which is fixed to the wheel KL, when it turns in the order BTA; but cannot turn the contrary way, by reason of a catch nailed to the end AB, which lays hold of the cross-bars in the wheel LK.

The weight by means of the cord QR, in consequence of its descent, carries about the barrel AB, which by the action of the catch carries the wheel KL, and this moves the pinion LM and wheel N, the latter moving the worm O and the fly P. Also the wheel LM carries the axis FD with the wheel DG, which carries the cord or chain that goes about the wheel or pulley at the head of the spit. But when the handle H gives motion to the axis in a contrary order to that given by the weight, the catch is depressed; so that although the barrel BC moves and winds the cord upon it, the wheel DG continues at rest. The time which the jack will continue in motion depends upon the number of pulleys at R and V: and as these increase or decrease, so must the weight which communicates the motion, in order to perform the same work in the same time.

Jack, *smoke*, is an engine used for the same purpose as the common jack; and is so called from its being moved by means of the smoke, or rarefied air, ascending the chimney, and striking against the sails of the horizontal wheel AB (Plate LXXII. Miscel. fig. 129), which being inclined to the horizon, is moved about the axis of the wheel, together with the pinion C, which carries the wheels D and E; and E carries the chain F, which turns the spit. The wheel AB should be placed in the narrow part of the chimney, where the motion of the smoke is swiftest, and where also the greatest part of it must strike upon the sails. The force of this machine depends upon the draught of the chimney, and the strength of the fire.

Smoke-jacks are sometimes moved by means of spiral flyers coiling about a vertical axle; and at other times by a vertical wheel with sails like the float-boards of a mill; but the above is the more customary construction.

JACK-flag, in a ship, that hoisted up at the sprit-sail top-mast head.

JACKALL. See Canis.

JACOB's staff, a mathematical instrument otherwise called cross-staff. See Cross.

JACOBITES, in church history, a sect of christians in Syria and Mesopotamia; so called either from Jacob, a Syrian, who lived in the reign of the emperor Mauricius; or from one Jacob, a monk, who flourished in the year 550.

JACOBUS, an ancient gold coin worth twenty-five shillings.

JACQUINIA, a genus of the monogynia order, in the hexandria class of plants; and in the natural method ranking with those of which the order is doubtful. The corolla is decemfid; the stamina inserted into the receptacle; the berry monospermous. There are four species, shrubs of South America.

JADE-stone, lapis nephriticus, or Jaspachates, a genus of siliceous earths. It gives fire with steel, and is semitransparent like flint. It does not harden in the fire, but melts in the focus of a burning-glass into a transparent green glass with some bubbles. A kind brought from the river of the Amazons in S. America, and called circoncision stone, melts more easily in the focus into a brown opaque glass, far less hard than the stone itself. The jade-stone is unctuous to the touch; whence Mr. Kirwan seems to suspect, that it contains a portion of argillaceous earth, or rather magnesia. The specific gravity is from 2.970 to 3.389; the texture granular,

with a greasy look, but exceedingly hard, being superior in this respect even to quartz itself. It is infusible in the fire, nor can it be dissolved in acids without a particular management; though M. Saussure seems to have extracted iron from it. Sometimes it is met with of a whitish milky colour from China; but mostly of a deep or pale green from America. The common lapis nephriticus is of a grey, yellowish, or olive colour. It has its name from a supposition of its being capable of giving ease in nephritic pains, by being applied externally by the loins. It may be distinguished from all other stones by its hardness, semipellucidity, and specific gravity.

According to Hoepfner it is composed of,

47	silica
38	carbonat of magnesia
9	iron
4	alumina
2	carbonat of lime
—	
100	

JALAP, *jalapa*, in botany, a plant of the pentandria monogynia class. See CONVOLVULUS, and MATERIA MEDICA.

JAMES, or *knights of St. James*, a military order in Spain, first instituted about the year 1170, by Ferdinand II. king of Leon and Galicia.

JANIZARIES, an order of the Turkish infantry, reputed the grand signior's guards, and the main strength of the Ottoman army.

JANSENISTS, in church-history, a sect of the Roman catholics in France, who follow the opinions of Jansenius, bishop of Ypres, and doctor of divinity of the universities of Louvain and Douay, nearly those of Calvin in relation to grace and predestination.

JAPANNING is properly the art of varnishing and painting ornaments on wood, in the same manner as is done by the natives of Japan in the East Indies.

The substances which admit of being japanned are almost every kind that are dry and rigid, or not too flexible; as wood, metals, leather, and paper, prepared for the purpose.

Wood and metals do not require any other preparation, but to have their surface perfectly even and clean; but leather should be securely strained, either on frames or on boards; as its bending, or forming folds, would otherwise crack and force off the coats of varnish. Paper should be treated in the same manner, and have a previous strong coat of some kind of size; but it is rarely made the subject of japanning till it is converted into papier mache, or wrought by other means into such form, that its original state, particularly with respect to flexibility, is changed.

One principal variation from the method formerly used in japanning is, the omitting any priming, or undercoat; on the work to be japanned. In the other practice, such a priming was always used; the use of which was to save in the quantity of varnish, by filling up the inequalities in the surface of the substance to be varnished. But there is a great inconvenience arising from the use of it, that the Japan coats are constantly liable to be cracked, and peeled off, by any violence, and will not endure near so long as the articles which are japanned without any such priming.

Of the nature of Japan grounds.—When a priming is used, the work should first be prepared by being well smoothed with fish-skin or glass-paper, and being made throughly clean, should be brushed over once or twice with hot size, diluted with two thirds water, if it is of the common strength. The priming should then be laid on as even as possible, and should be formed of a size, of a consistency between the common kind and glue, mixed with as much whiting as will give it a sufficient body of colour to hide the surface of whatever it is laid upon, but not more. This must be repeated till the inequalities are completely filled up, and then the work must be cleaned off with Dutch rushes, and polished with a wet rag.

When wood or leather is to be japanned, and no priming is used, the best preparation is to lay two or three coats of coarse varnish, composed in the following manner.

Take of rectified spirit of wine one pint, and of coarse seed-lac and resin each two ounces; dissolve the seed-lac and resin in the spirit, and then strain off the varnish.

This varnish, as well as all others formed of spirit of wine, must be laid on in a warm place; and if it can be conveniently managed, the piece of work to be varnished should be made warm likewise; and for the same reason, all dampness should be avoided; for either cold or moisture chills this kind of varnish, and prevents its taking proper hold of the substance on which it is laid.

When the work is so prepared, or by the priming with the composition of size and whiting above described, the proper japan ground must be laid on, which is much the best formed of shell-lac varnish, and the colour desired, except white, which requires a peculiar treatment; and if brightness is wanted, then also other means must be pursued.

The colours used with the shell-lac varnish may be any pigments whatever, which give the tint of the ground desired.

As metals never require to be under-coated with whiting, they may be treated in the same manner as wood or leather.

Method of painting Japan work.—Japan work ought properly to be painted with colours in varnish; though, for the greater dispatch, and in some very nice work in small, for the freer use of the pencil, the colours are sometimes tempered in oil; which should previously have a fourth part of its weight of gum animi dissolved in it; or in default of that gum sandarach, or gum mastich. When the oil is thus used, it should be well diluted with oil of turpentine, that the colours may lie more evenly and thin; by which means fewer of the polishing or upper coats of varnish become necessary.

In some instances, water-colours are laid on grounds of gold, in the manner of other paintings; and are best, when so used in their proper appearance, without any varnish over them; and they are also sometimes so managed as to have the effect of embossed work. The colours employed in this way, for painting, are best prepared by means of isinglass size, corrected by honey or sugar-candy. The body, of which the embossed work is raised, need not, however, be tinged with the exterior colour, but may be best formed of very strong gum-water, thickened to a proper consistence by bole armenian and

whiting in equal parts; which being laid on the proper figure, and repaired when dry, may be then painted with the proper colours, tempered with the isinglass size, or, in the usual manner, with shell-lac varnish.

Manner of varnishing japan work.—The finishing of japan-work depends on the laying on, and polishing, the outer coats of varnish which are necessary, as well in the pieces that have only one simple ground of colour, as with those that are painted. This is in general done best with common seed-lac varnish, except in the instances, and on those occasions, where particular methods are deemed to be more expedient; and the same reasons which decide as to the fitness or impropriety of the varnishes, with respect to the colours of the ground, hold equally with regard to those of the painting. For where brightness is the most material point, and a tinge of yellow will injure it, seed-lac must give way to the whiter gums; but where hardness and a greater tenacity are most essential, it must be adhered to; and where both are so necessary, that it is proper one should give way to the other in a certain degree reciprocally, a mixed varnish must be adopted.

This mixed varnish, as we have already observed, should be made of the picked seed-lac. The common seed-lac varnish, which is the most useful preparation of the kind hitherto invented, may be thus made.

Take of seed-lac three ounces, and put it into water, to free it from the sticks and filth that are frequently intermixed with it; and which must be done by stirring it about, and then pouring off the water, and adding fresh quantities, in order to repeat the operation, till it is freed from all impurities, as is very effectually done by this means. Dry it then, and powder it grossly, and put it, with a pint of rectified spirit of wine, into a bottle, of which it will not fill above two-thirds. Shake the mixture well together, and place the bottle in a gentle heat, till the seed-lac appears to be dissolved; the shaking being in the mean time repeated as often as may be convenient; and then pour off all that can be obtained clear by this method, and strain the remainder through a coarse cloth. The varnish thus prepared, must be kept for use in a bottle well stopped.

When the spirit of wine is very strong, it will dissolve a greater proportion of the seed-lac; but this quantity will saturate the common, which is seldom of a strength sufficient to make varnishes in perfection. As the chilling, which is the most inconvenient accident attending varnishes of this kind, is prevented or produced more frequently, according to the strength of the spirit; we shall therefore take this opportunity of showing a method by which weaker rectified spirits may with great ease at any time be freed from the phlegm, and rendered of the first degree of strength.

Take a pint of the common rectified spirit of wine, and put it into a bottle, of which it will not fill above three parts; add to it half an ounce of pearl-ashes, salt of tartar, or any other alkaline salt, heated red-hot, and powdered as well as it can be without much loss of its heat. Shake the mixture frequently for the space of half an hour; before which time, a great part of the phlegm will be separated from the spirit, and will appear, together with the undissolved part of the salts, in the bottom of the bottle. Let the spirit be poured off, or freed from the phlegm and the salts, by means of a tritorium, or separating funnel; and let half an ounce of the pearl-ashes, heated and powdered as before, be added to it, and the same treatment repeated. This may be done a third time, if the quantity of phlegm separated by the addition of the pearl-ashes appears considerable. An ounce of alum reduced to powder, and made hot, but not burnt, must then be put into the spirit, and suffered to remain some hours, the bottle being frequently shaken: after which the spirit, being poured off from it, will be fit for use.

The addition of the alum is necessary to neutralize the remains of the alkaline salt, which would otherwise greatly deprave the spirit, with respect to varnishes and lacquer where vegetable colours are concerned, and must consequently render another distillation necessary.

The manner of using the seed-lac, or white varnish, is the same, except with regard to the substance used in polishing: which, where a pure white of a great clearness of other colours is in question, should be itself white; whereas the browner sorts of polishing-dust, as being cheaper, and doing their business with greater despatch, may be used in other cases. The pieces of work to be varnished, should be placed near a fire, or in a room where there is a stove, and made perfectly dry; and then the varnish may be rubbed over them by the proper brushes made for that purpose, beginning in the middle, and passing the brush to one end, and then with another stroke from the middle, passing it to the other. But no part should be crossed, or twice passed over, in forming one coat, where it can be possibly avoided. When one coat is dry, another must be laid over it; and this must be continued at least five or six times, or more, if on trial, there is not sufficient thickness of varnish to bear the polish, without laying bare the painting or ground-colour underneath.

When a sufficient number of coats is thus laid on, the work is fit to be polished; which must be done, in common cases, by rubbing it with a rag dipped in tripoli, or rottenstone, finely powdered; but, towards the end of the rubbing, a little oil of any kind should be used along with the powder; and when the work appears sufficiently bright and glossy, it should be well rubbed with the oil alone, to clean it from the powder, and give it a still brighter lustre.

JARGON. See Zircon.

JASIONE, a genus of the monogamia order, in the sygenesia class of plants, and in the natural method ranking under the 49th order, campanaceæ. The common calyx is ten-leaved; and the corolla has five regular petals; the capsule beneath, two-celled. There are four species, shrubs of the West Indies.

JASMINUM, Jasmine, or Jessamine tree, a genus of the monogynia order, in the diandria class of plants, and in the natural method ranking under the 44th order, sepiariæ. The corolla is salver-shaped, the berry dicoccous; the seeds arillated, the antheræ within the tube. There are 17 species. The most remarkable are: 1. The officinalis, or common white jasmine, with shrubby long slender stalks and branches, rising upon supports 15 or 20 feet high, with numerous white flowers from the joints and ends, of a very fragrant odour. There is a variety with white-striped, and another with yellow-striped

sail extended from the outer end of the bowsprit prolonged by the jib-boom, towards the fore-top-mast head. See SAIL.

JIB-*boom*, a boom run out from the extremity of the bowsprit, parallel to its length, and serving to extend the bottom of the jib, and the stay of the fore-top-gallant-mast.

JOINT ACTIONS: in personal actions, several wrongs may be joined in one writ; but actions founded upon a tort and a contract cannot be joined, for they require different pleas and different process. 1 Vent. 336.

JOINT AND SEVERAL: an interest cannot be granted jointly and severally; as if a man grants the next advowson, or makes a lease for years, to two jointly and severally; these words (severally) are void, and they are joint tenants. 5 Rep. 19.

JOINT LIVES: lease for years to husband and wife, if they or any issue of their bodies should so long live, has been adjudged so long as either the husband, wife, or any of their issue, should live; and not only so long as the husband and wife, &c. should jointly live. Moor, 539.

JOINT TENANTS, are those that come to, and hold lands or tenements by one title pro indiviso, or without partition.

These are distinguished from sole or several tenants, from parceners, or from tenants in common: and they must jointly implead, and jointly be impleaded by others, which properly is common between them and coparceners; but joint tenants have a sole quality of survivorship, which coparceners have not; for if there are two or three joint tenants, and one has issue and dies, then he or those joint tenants that survive, shall have the whole by survivorship. Cowel.

The creation of an estate in joint tenantcy depends on the wording of the deed or device, by which the tenant claims title; for this estate can only arise by purchase or grant, that is, by the act of the parties; and never by the mere act of law. Now if any estate is given to a plurality of persons, without adding any restrictive, exclusive, or explanatory words, as if an estate is granted to A and B and their heirs, this makes them immediately joint tenants in fee of the lands; for the law interprets the grant, so as to make all parts of it take effect, which can only be done by creating an equal estate in them both. As therefore the grantor has thus united their names, the law gives them a thorough union in all other respects. 2 Black. 180.

If there are two joint tenants, and one releases the other, this passes a fee without the word heirs; because it refers to the whole fee, which they jointly took, and are possessed of by force of the first conveyance; but the tenants in common cannot release to each other, for a release supposes the party to have the thing in demand, but tenants in common have several distinct freeholds, which they cannot transfer otherwise than as persons who are sole seized. Co. Lit. 9.

Although joint tenants are seized per mie et per tout, yet to divers purposes each of them has but a right to a moiety; as to enfeoff, give, or demise, or to forfeit or lose by default in a præcipe; and therefore where there are two or more joint tenants, and they all join in a feoffment, or each of them in judgment gives but his part. Co. Lit. 186.

The right of survivorship shall take place immediately upon the death of the joint tenant, whether it is a natural or civil death; as if there was no joint tenants, and one of them enters into religion, the survivor shall have the whole. Co. Lit. 181.

At common law, joint tenants in common were not compellable to make partition, except by the custom of some cities and boroughs. Co. Lit. 187.

But now joint tenants may make partition; the one party may compel the other to make partition, which must be by deed: that is to say, all the parties must by deed actually convey and assure to each other the several estates, which they are to take and enjoy severally and separately. 2 Black. 324.

Joint tenants being seized per mie et per tout, and deriving by one and the same title, must jointly implead, and be jointly impleaded with others. Co. Lit. 180.

If one joint tenant refuses to join in action, he may be summoned and severed; but herein it is to be observed, that if the person severed dies, the writ abates, because the survivor then goes for the whole, which he cannot do on that writ, where on the summons and severance he went only for a moiety before; for the writ cannot have a double effect, to wit, for a moiety in case of summons and severance, and for the whole in case of survivorship. Co. Lit. 188.

But in personal and mixed actions where there is summons and severance, and yet after such summons and severance the plaintiff goes on for the whole, there if one of them dies, yet the writ shall not abate, because they go on for the whole after summons and severance; and if they were to have a new writ, it would only give the court authority to go on for the whole. Co. Lit. 197.

JOINTURE. A jointure strictly speaking; signifies a joint estate, limited to both husband and wife; but in common acceptation, it extends also to a sole estate, limited to the wife only, and may be thus defined, viz. a competent livelihood of freehold for the wife of lands and tenements, to take effect, in profit or possession, presently after the death of the husband; for the life of the wife at least. 2 Black. 137.

By the statute of the 27th H. VIII. c. 10, if a jointure is made to the wife, it is a bar of her dower, so that she shall not have both jointure and dower. And to the making of a perfect jointure within that statute six things are observed: 1. Her jointure is to take effect presently after her husband's decease. 2. It must be for the term of her own life, or greater estate. 3. It should be made to herself. 4. It must be made in satisfaction of her whole dower, and not of part of her dower. 5. It must either be expressed or averred to be in satisfaction of her dower. 6. It should be made during the coverture. 1 Inst. 32.

The estate must take effect presently after her husband's disease; therefore if an estate is made to the husband for life, remainder to another person for life, remainder to the wife for her jointure, this is no good jointure, for it is not within the words or intent of the statute; for the statute designed nothing as a satisfaction for dower, but that which came in the same place, and is of the same use to the wife; and though the other person dies during the life of the husband, yet this is not good; for every interest not equivalent to dower not being

within the statute, is a void limitation to deprive the wife of her dower. 4 Co. 3.

The estate must be for the term of the wife's life, or a greater estate; therefore if an estate is made for the life or lives of many others, this is no good jointure; for if she survives such lives, as she may, then it would be no competent provision during her life, as every jointure within the statute ought to be. Co. Lit. 36.

The estate should be made to herself; but as the intention of the statute was to secure the wife a competent provision, and also to exclude her from claiming dower, and likewise her settlement, it seems that a provision or settlement on the wife, though by way of trust, if in other respects it answers the intention of the statute, will be inforced in a court of equity.

The estate must be in satisfaction of the whole dower; the reason hereof is, that if it is made in satisfaction of part only, it is uncertain for what part it is in satisfaction of her dower, and therefore void in the whole. Co. Lit. 36.

The estate must be expressed or averred to be in satisfaction of her dower. Lord Coke says, that it must be expressed or averred to be in satisfaction of her dower; but quære, for this does not seem requisite either within the words or intention of the statute. Co. Lit. 36.

It should be made during the coverture; this the very words of the act of parliament require: and therefore if a jointure is made to a woman during her coverture in satisfaction of dower, she may wave it after her husband's death; but if she enters and agrees thereto, she is concluded; for though a woman is not bound by any act when she is not at her own disposal, yet if she agrees to it when she is at liberty, it is her own act, and she cannot avoid it. Co. Lit. 36. 4 Co. 3.

JOISTS, or Joysts. See Architecture.

JONCQUETIA, a genus of the decandria tetragynia class and order. The cal. is five-leaved; pet. five and spreading; filaments growing to a glandule; styles none; caps. sub-globular, one-celled, five-valved, five-seeded. There is one species, a large tree of Guiana.

JONK, or Jonque, in naval affairs, is a kind of small ship, very common in the East Indies: these vessels are about the bigness of our fly-boats, and differ in the form of their building, according to the different methods of naval architecture used by the nations to which they belong. Their sails are frequently made of mats, and their anchors are made of wood.

JOURNAL, at sea. See Navigation.

JUDGE. The judges are the chief magistrates in the law, to try civil and criminal causes. Of these there are twelve in England, viz. the lords chief justices of the courts of king's-bench and common-pleas; the lord chief baron of the exchequer; the three puisne or inferior judges of the two former courts, and the three puisne barons of the latter.

By stat. 1 Geo. III. c. 23. the judges are to continue in their offices during their good behaviour, notwithstanding any demise of the crown (which was formerly held immediately to vacate their seats), and their full salaries are absolutely secured to them during the continuance of their commissions, by which means the judges are rendered completely independant of the king, his ministers, or his successors.

A judge at his creation takes an oath, that he will serve the king, and indifferently administer justice to all men, without respect of persons, take no bribe, give no counsel where he is a party, nor deny right to any, though the king or any other, by letters, or by expressed words, command the contrary, &c. and in default of duty, to be answerable to the king in body, land, and goods.

Where a judge has an interest, neither he nor his deputy can determine a cause, or sit in court; and if he does, a prohibition lies. Hardw. 503.

Judges are punishable for wilful offences, against the duty of their situations; instances of which happily live only in remembrance. There are ancient precedents of judges who were fined when they transgressed the laws, though commanded by warrants from the king.

Judge is not answerable to the king, or the party, for mistakes or errors of his judgment, in a matter of which he has jurisdiction. 1 Salk. 397.

JUDGMENT. The opinion of the judges is so called, and is the very voice and final doom of the law, and therefore is always taken for unquestionable truth; or it is the sentence of the law pronounced by the court, upon the matter contained in the record.

Judgments are of four sorts, viz. 1. Where the facts are confessed by the parties, and the law determined by the court, which is termed judgment by demurrer.

2. Where the law is admitted by the parties, and the facts only are disputed, as in judgment upon a demurrer.

3. Where both the fact and the law arising thereon are admitted by the defendant, as in case of judgment by confession or default.

4. Where the plaintiff is convinced that fact or law, or both, are insufficient to support his action, and therefore abandons or withdraws his prosecution, as in case of judgment upon a nonsuit or retraxit. See Warrant of Attorney.

Judgments are either interlocutory or final.

Interlocutory judgments are such as are given in the middle of a cause, upon some plea, proceeding, or default, which is only intermediate, and does not finally determine or complete the suit; as upon dilatory pleas, when the judgment in many cases is, that the defendant shall answer over; that is, put in a more substantial plea.

Final judgments, are such as at once put an end to the action, by declaring that the plaintiff has either entitled himself, or has not, to recover the remedy he sues for. 3 Black. 398.

JUGERUM, in Roman antiquity, a square of 120 Roman feet; its proportion to the English acre being as 10,000 to 16,097.

JUGLANS, the walnut, a genus of the monœcia class, and polyandria order of plants; and in the natural method ranking under the 50th order, amentaceæ. The male calyx is monophyllous, and squamiform; the corolla divided into six parts; there are 18 filaments: the female calyx is quadrifid, superior; the corolla quadripartite; there are two styles, and the fruit is a plum with a furrowed kernel. There are 8 species, the most remarkable of which is the regia or common walnut. Other two species, called the nigra and alba, or black and white Virginian walnut, are also cultivated in this country, though they are less proper for fruit, having very small kernels.

fits of his land during life, and suffer perpetual imprisonment.

Jury-mast, whatever is set up in room of a mast that has been lost in a storm or in an engagement, and to which a lesser yard, ropes, and sails, are fixed.

JUSSIÆA, a genus of the monogynia order, in the decandria class of plants; and in the natural method ranking under the 17th order, calycanthemæ. The calyx is quadripartite, or quinquepartite superior; there are four or five petals; the capsule quadrilocular or quinquelocular, oblong, opening at the angles: the seeds are numerous and small. There are 11 species, mostly herbaceous plants of the W. Indies.

JUSTICE, in a legal sense, a person deputed by the king to administer justice to his subjects, whose authority arises from his deputation, and not by right of magistracy.

In the courts of king's bench and common pleas there are two judges styled chief justices, each of whom retains the title of lord during the time of his continuing in office. The first of these, who is styled lord chief justice of England, has a very extensive power and jurisdiction in pleas of the crown. He hears all pleas in civil causes brought before him in the court of king's bench, and also the pleas of the crown; while, on the other hand, the lord chief justice of the common pleas has the hearing of all civil causes between common persons. Besides the lords chief justices, there are in each of the above courts three puisne justices; there are also several other justices appointed by the king for the execution of the laws; such as the lords justices in eyre of the forests, who are two justices appointed to determine all offences committed in the king's forests; justices of assize, of oyer and terminer, of gaol-delivery, &c. They are also called justices of nisi prius, and so denominated from the words usual in a common form of adjournment of a cause in the court of common pleas. See Nisi Prius, Oyer and Terminer, Common Pleas, and King's Bench.

Justices *of the Peace*. See Peace.

JUSTICIARY, or court of Justiciary, in Scotland, a court of supreme jurisdiction in all criminal cases.

This court came in place of the justice-eyre or justice-general, which last was taken away by parliament in 1672, and was erected into a justice or criminal court, consisting of a justice-general alterable at the monarch's pleasure, justice clerk, and five other judges, who are lords of session.

This court commonly sits upon Mondays, and has an ordinary clerk, who has his commission from the justice-clerk. They have four macers, and a doomster appointed by the lords of the session.

The form of the process is this: the clerk raises a libel or indictment upon a bill passed by any of the lords of that court, at the instance of the pursuer, against the defendant or criminal, who is immediately committed to prison after citation. When the party, witnesses, great assize, or jury of forty-five men, are cited, the day of compearance being come, fifteen of the great assize are chosen to be the assize upon the pannel, or prisoner at the bar. The assize sits with the judges to hear the libel read, witnesses examined, and the debates on both sides, which are written verbatim in the adjournal books. The king's advocate pleads for the pursuer, being the king's cause, and other advocates for the pannel. The debates being closed, the judges find the libel or indictment either non-relevant, in which case they desert the diet, and assoil or absolve the party accused; or, if relevant, then the assize or jury of fifteen is removed into a closer room, none being present with them, where they choose their chancellor and clerk, and consider the libel, deposition, and debates; and bring in their verdict of the pannel sealed, guilty or not guilty: if not guilty, the lords absolve; if guilty, they condemn and declare their sentence of condemnation, and command the sentence to be pronounced against the pannel by a macer and the mouth of the doomster. The lords of the justiciary likewise go circuits twice a year into the country. See the article Circuit.

JUSTICIES, a writ directed to a sheriff, by virtue of which he is empowered to hold a plea of debt in his county-court for a sum above 40*s.* though by his ordinary power he has only cognizance of sums under 40*s.*

JUSTIFICATION, in law, is an affirming or showing good reason in court, why one does such a thing as he is called to answer; as to justify in a cause of a replevin.

JUSTICIA, Malabar nut; a genus of the monogynia order, in the diandria class of plants; and in the natural method ranking under the 40th order, personatæ. The corolla is ringent; the capsule bilocular, parting with an elastic spring at the heel; the stamina have only one anthera. There are eighty species, most of them natives of the East Indies, growing many feet high; some adorned with fine large leaves, others with small narrow ones, and all of them with monopetalous ringent flowers. Only two species are commonly cultivated in our gardens, viz. the adhatoda, or common Malabar nut, and the hyssopifolia or snap-tree. The first grows ten to twelve feet high, with a strong woody stem; and from the ends of the branches short spikes of white flowers, with dark spots, having the helmet of the corolla concave. The second has a shrubby stem, and white flowers, commonly by threes, from the sides of the branches; succeeded by capsules, which burst open with elastic force for the discharge of the seeds; whence the name of snap-tree.

JYNX, the wryneck, a genus of birds belonging to the order of picæ; the characters of which are, that the bill is slender, round, and pointed; the nostrils are concave and naked; the tongue is very long, very slender, cylindric, and terminated by a hard point; and the feet are formed for climbing. There is only one species, viz. the torquilla. The colours of this bird are elegantly pencilled, though its plumage is marked with the plainest colours. The wryneck, Mr. Pennant apprehends, is a bird of passage, appearing with us in the spring before the cuckoo. Its note is like that of the kestril, a quick-repeated squeak; its eggs are white, with a very thin shell; it builds in the hollows of trees, making its nest of dry grass. It has a very whimsical way of turning and twisting its neck about, and bringing its head over its shoulders, whence it had its Latin name torquilla, and its English one of wryneck.

K.

K, or k, the tenth letter of our alphabet; as a numeral, denotes 250; and with a line over it, $\overline{K}$, 250000.

KÆMPFERIA, *zedoary*, a genus of the monogynia order, in the monandria class of plants, and in the natural method ranking under the eighth order, scitamineæ. The corolla is sexpartite, with three of the segments larger than the rest, patulous; and one only bipartite. The species are, 1. The galanga, common galangal, or long zedoary. 2. The rotunda, or round zedoary. Both are perennial in root; but the leaves rise annually in spring, and decay in winter. They flower in summer; each flower is of one petal, tubulous below, but plain above, and divided into six parts; they continue three or four weeks in beauty, but are never succeeded by seeds in this country. Both these plants must be potted in light rich mould, and always kept in the hot-house.

KALI, a genus of marine plants, which are burnt to procure mineral alkali.

KALMIA, a genus of the monogynia order, in the decandria class of plants, and in the natural method ranking under the 18th order, bicornes. The calyx is quinquepartite; the corolla salver-shaped, formed with five nectariferous horns on the under or outer side; the capsule quinquelocular. Of this genus there are four species. Those chiefly in cultivation with us are,

1. The latifolia, a most beautiful shrub, which rises usually to the height of five or six feet, and sometimes twice that height in its native places. The flowers grow in bunches on the tops of the branches to footstalks three inches long; they are white, stained with purplish red, consisting of one petal in form of a cup, divided at the verge into five sections; in the middle are a stylus and 12 stamina, which, when the flower first opens, appear lying close to the sides of the cup at equal distances, their apices being lodged in 10 little hollow cells, which being prominent on the outside, appear as so many little tubercles. This plant is a native of Carolina, Virginia, and other parts of the northern continent of America, yet is not common, but found only in particular places; it grows on rocks hanging over rivulets and running streams, and on the sides of barren hills.

2. The angustifolia, rises to the height of about 16 feet, with evergreen leaves. The flowers grow in clusters, and when blown, appear white; but on a near view, are of a faint bluish colour, which as the flower decays grows paler.

KAOLIN, the name of an earth which is used as one of the two ingredients in oriental porcelain. See PORCELAIN.

KECKLE, or KECKLING, in the sea language, is the winding of old ropes about cables, to prevent them from galling.

KEDGING, in the sea-language, is when a ship is brought up or down a narrow river by means of the tide, the wind being contrary.

KEEL, the lowest piece of timber in a ship, running her whole length from the lower part of her stem to the lower part of her stern-post. Into it are all the lower futtocks fastened; and under part of it, a false keel is often used.

KEELSON, a principal timber in a ship, fayed withinside cross all the floor-timbers; and being adjusted to the keel without suitable scarfs, it serves to strengthen the bottom of the ship.

KEEP, in ancient military history, a kind of strong tower which was built in the centre of a castle or fort, to which the besieged retreated, and made their last efforts of defence. Of this description is the keep of Windsor castle.

KEEPER *of the great seal*, is a lord by his office, is styled lord-keeper of the great seal of Great Britain, and is always one of the privy council. All grants, charters, and commissions of the king under the great seal, pass through the hands of the lord-keeper, for without that seal many of those grants, &c. would be of no force, the king being, in the interpretation of the law, a corporation, and therefore passing nothing but by the great seal, which is also said to be the public faith of the kingdom, being in the highest esteem and reputation. Whenever there is a lord-keeper, he is invested with the same place, authority, pre-eminence, jurisdiction, or execution of laws, as the lord chancellor of Great Britain is vested with.

KEEPER *of the privy seal*. See PRIVY SEAL.

KEISELSCHIEFER. This mineral occurs usually in blocks and amorphous masses of different sizes; very often in the beds of rivers: colour various shades of grey: structure slaty: usually opaque: brittle: specific gravity from 2.880 to 2.415: infusible per se. This species is divided into two subspecies.

Keiselschiefer, common: colour blackish grey or greenish: often traversed by veins of quartz: surface smooth: texture compact: fracture splintery, or imperfectly conchoidal: composed according to Wiegleb of

75.00	silica
10.00	lime
4.58	magnesia
3.54	iron
5.02	inflammable matter
98.14	

Lydian stone is another species of keiselschiefer: commonly intersected by veins of quartz: fracture even: sometimes inclining to conchoidal: specific gravity 2.596: powder black: colour greyish black.

This, or a stone similar to it, was used by the ancients as a touchstone. They drew the metal to be examined along the stone, and judged of its purity by the colour of the metallic streak. On this account they called it βασανος, "the trier." They called it also Lydian-stone, because, as Theophrastus informs us, it was found most abundantly in the river Tmolus in Lydia.

KELP, in the glass trade, a term used for a sort of potass made use of in many of the glass works, particularly for the green glass. It is the calcined ashes of a

plant called by the same name; and in some places of sea-tangs or laces, a sort of thick-leaved fucus or sea-wrack. This plant is thrown on the rocks and shores in great abundance, and in the summer months is raked together and dried as hay in the sun and wind, and afterwards burned to the ashes called kelp.

KEMO, a shell found on the coast of Sumatra; it is sometimes three or four feet in diameter, as white as ivory. See Marsden's Hist. of Sumatra.

KENKS, in the sea-language, doublings in a rope or cable, when handed in and out, so that it does not run easy; or when any rope makes turns or twists, and does not run free in the block.

KERATOPHYTUM, in natural history. See CORALLINES.

KERMES. See COCCUS.

KERMES MINERAL, a compound of sulphuret of antimony and potass.

KETCH, in naval architecture, a vessel with two masts, usually applied to one carrying bombs, or rather mortars.

KEVEL, in ship-building, a piece of plank fayed against the quickwork on the quarter-deck, in the shape of a semicircle; about which the running rigging is belaid.

KEY, in music, a fundamental note or tone to which the whole of a movement has a certain relation or bearing, to which all its modulations are referred and accommodated, and in which it both begins and ends. There are but two species of keys, one of the major, and one of the minor mode; all the keys in which we employ sharps or flats being deduced from the natural keys of C major, and A minor, of which indeed they are only transpositions.

KEY-STONE. See ARCHITECTURE.

KEYS. See ORGAN, HARPSICHORD, &c.

KIDKNAPPING, is the forcible taking and carrying away a man, woman, or child, from their own country, and sending them to another. This is an offence at common law, and punishable by fine, imprisonment, and pillory.

By stat. 11 and 12 W. III. c. 7, if any captain of a merchant vessel shall during his being abroad force any person on shore, and wilfully leave them behind, or refuse to bring home all such men as he carried out, if able and desirous to return, he shall suffer three months imprisonment. Exclusive of the above punishment for this as a criminal offence, the party may recover upon an action for compensation in damages for the civil injury.

KIDNEYS. See ANATOMY.

KIFFEKIL. This mineral is dug up near Konie in Natolia, and is employed in forming the bowls of Turkish tobacco-pipes. The sale of it supports a monastery of dervises established near the place where it is dug. It is found in a large fissure six feet wide, in grey calcareous earth. The workmen assert that it grows again in the fissure, and puffs itself up like froth. This mineral, when fresh dug, is of the consistence of wax; it feels soft and greasy; its colour is yellow; its specific gravity 1.600: when thrown on the fire it sweats, emits a fetid vapour, becomes hard, and perfectly white.

According to the analysis of Klaproth, it is composed of

50.50	silica
17.25	magnesia
25.00	water
5.00	carbonic acid
.50	lime.
98.25	

KIGGELARIA, a genus of the decandria order, in the diœcia class of plants, and in the natural method ranking under the 37th order, columniferæ. The male calyx is quinquepartite; the corolla pentapetalous; there are five trilobous glandules; the antheræ are perforated at top; the female calyx and corolla as in the male; there are five styles; the capsule unilocular, quinquevalved, and polyspermous. There is but one species, viz. the Africana. As this is a native of warm climates, it must be constantly kept in a stove in this country. It is propagated by seeds, layers, or cuttings, though most readily by seeds.

KILDERKIN, a liquid measure containing two firkins, or 18 gallons.

KINDRED. See DESCENT.

KING, signifies him who has the highest power and absolute rule over the whole land; and therefore the king is, intendment of law, cleared of those defects which common persons are subject to; for he is always supposed to be of full age, though ever so young. He pardons life and limb to offenders against the crown and dignity, except such as he binds himself by oath not to forgive. The law ascribes to his majesty, in his political capacity, an absolute immortality. The king never dies. For immediately on the decease of the reigning prince in his natural capacity, his imperial dignity, by act of law, without any interregnum or interval, is vested at once in his heir, who is eo instanti king to all intents and purposes. And so tender is the law of supposing even a possibility of his death, that his natural dissolution is generally called his demise, an expression signifying merely a transfer of property. Plowd. 177.

By the articles of the union of the two kingdoms of England and Scotland, all papists, and persons marrying papists, are for ever excluded from the imperial crown of Great Britain; and in such case, the crown shall descend to such person being a protestant, as should have inherited the same, in case such papist, or person marrying a papist, was naturally dead. 5 Anne, c. 8.

KING'S BENCH. The king's bench is the supreme court of common law in the kingdom, and is so called because the king used to sit there in person; it consists of a chief justice, and three puisne justices, who are by their office the sovereign conservators of the peace, and supreme coroners of the land.

This court has a peculiar jurisdiction, not only over all capital offences, but also over all other misdemeanours of a public nature, tending either to a breach of the peace, or to oppression, or faction, or any manner of misgovernment. It has a discretionary power of inflicting exemplary punishment on offenders, either by fine, imprisonment, or other infamous punishment, as the nature of the crime, considered in all its circumstances, shall require.

The jurisdiction of this court is so transcendant, that it keeps all inferior jurisdictions within the bounds of

their authority; and it may either remove their proceedings to be determined here, or prohibit their progress below: it superintends all civil corporations in the kingdom; commands magistrates and others to do what their duty requires, in every case where there is no specific remedy; protects the liberty of the subject, by speedy and summary interposition; takes cognizance both of criminal and civil causes; the former in what is called the crown side, or crown office; the latter in the plea side of the court.

This court has cognizance on the plea side of all actions of trespass, or other injury alleged to be committed vi et armis; of actions for forgery of deeds, maintenance, conspiracy, deceit, and actions on the case which allege any falsity or fraud.

In proceedings in this court, the defendant is arrested for a supposed trespass, which in reality he has never committed; and being thus in the custody of the marshal of this court, the plaintiff is at liberty to proceed against him for any other personal injury, which surmise of being in the custody of the marshal, the defendant is not at liberty to dispute.

This court is likewise a court of appeal; into which may be removed, by writ of error, all determinations of the court of common pleas, and of all inferior courts of record in England.

King's bench prison. King's bench new rules. East. 30 G. III. it is ordered by the court, that from and after the first day of Trinity term next, the rule made in the sixth year of the reign of king George I. and all other rules for establishing the rules of the king's bench prison, shall be, and the same are hereby repealed. And it is farther ordered, that from and after the said first day of Trinity term next, the rules of the king's bench prison shall be comprized within the bounds following, exclusive of the public houses hereinafter mentioned; that is to say, from Great Camber-court in the parish of St. George the Martyr, in the county of Surry, along the north side of Dirty-lane, and Melancholy-walk, to Blackfriar's-road, along the western side of the said road to the obelisk, and thence along the south-west side of the London-road, round the direction post in the centre of the roads, near the public house known by the sign of the Elephant and Castle, and thence along the eastern side of Newington causeway to Great Cumber-court aforesaid: and it is also ordered, that the new gaol Southwark, and the highway, exclusive of the houses on each side of it, leading from the king's bench prison to the said new gaol, shall be within and part of the said rules. And it is lastly ordered, that all taverns, victualling-houses, ale-houses, and wine vaults, and houses or places licensed to sell gin, or other spirituous liquors, shall be excluded out of, and deemed no part of the said rules. It is ordered, that from and after the first day of Trinity term next, no prisoner in the king's bench prison, or within the rules thereof, shall have, or be entitled to have, day rules above three days in each term. And it is further ordered, that every such prisoner having a day rule, shall return within the walls or rules of the said prison, at or before nine o'clock in the evening of the day on which such rule shall be granted.

King's palace. The limits of the king's palace at Westminster extend from Charing-cross to Westminster-hall, and shall have such privileges as the ancient palaces. 28 H. VIII. c. 12.

King's fisher. See Alcedo.

KLINGSTEIN: this mineral composes whole mountains. They are usually insulated; and like basalt, show a tendency to assume the form of four-sided prisms. Its colour is usually deep grey, of various shades; but most commonly greenish. Sometimes various shades appear together, which gives it the appearance of being spotted. Found not only constituting mountains, but also in globular masses, &c. Internal lustre arises chiefly from some crystals of hornblende and felspar which it contains. Structure slaty. Texture compact. Fracture usually splintery; sometimes conchoidal. Brittle. Gives a clear sound when struck with a hammer. Specific gravity 2.575. Powder light grey. Melts easily into a glass. A specimen analysed by Klaproth yielded

57.25	silica
23.50	alumina
2.75	lime
3.25	oxide of iron
0.25	oxide of manganese
8.10	soda
3.00	water
98.10	

KLEINHOVIA, a genus of the class and order gynandria decandria; the calyx is five-leaved; corolla five-petalled; nect. bell-shaped; caps. inflated, five-lobed. There is one species, a tree of Java.

KNAPSACK, a rough leather or canvas bag, which is strapped to an infantry soldier's back when he marches, and which contains his necessaries. Square knapsacks are supposed to be most convenient. They should be made with a division to hold the shoes, blacking-balls, and brushes, separate from the linen. White goat-skins are sometimes used, but we do not conceive them to be equal to the painted canvas ones. Soldiers are put under stoppages for the payment of their knapsacks, which after six years become their property.

KNAUTIA, a genus of the monogynia order, in the tetrandria class of plants, and in the natural method ranking under the 48th order, aggregatæ. The common calyx is oblong, simple, quinqueflorous; the proper one simple, superior; the florets irregular; the receptacle naked. There are four species, chiefly annuals of the Levant.

KNEE. See Anatomy.

Knee, in a ship, a crooked piece of timber, bent like a knee, used to bend the beams and futtocks together, by being bolted fast into them both. These are used about all the decks.

KNEES, *carling*, in a ship, those timbers which extend from the sides to the hatchway, and bear up the deck on both sides.

KNIGHT, properly signifies a person, who, for his virtue and martial prowess, is by the king raised above the rank of gentleman into a higher class of dignity and honour. The ceremonies at the creation of knights have been various; the principal was a box on the ear, and a stroke with a sword on the shoulder; they put on him a shoulder-belt, and a gilt sword, spurs, and other military accoutrements; after which, being armed as a knight, he was led to the church in great pomp. Camden describes

the manner of making a knight-bachelor, which is the lowest, though the most ancient order of knighthood, to be thus: the person kneeling was gently struck on the shoulder by the prince, and accosted in these words, "rise," or "be a knight in the name of God." For the several kinds of knights among us, see BANNERET, BARONET, BATH, GARTER, &c.

KNIGHTS *of the shire*, or KNIGHTS *of parliament*, in the British polity, are two knights or gentlemen of estate, who are elected on the king's writ, by the freeholders of every county, to represent them in parliament. The qualification of a knight of the shire is to be possessed of 600*l.* per ann. in a freehold estate. Their expenses during their sittings were by a statute of Henry VIII. to be defrayed by the county; but this is now never required.

KNIGHT-MARSHAL, an officer in the king's household, who has jurisdiction and cognizance of any transgression within the king's household and verge; as also of contracts made there, whereof one of the house is party.

KNIGHTS, in a ship, two thick short pieces of wood, commonly carved like a man's head, having four shivers in each, three for the halyards, and one for the top-ropes to run in; one of them stands fast bolted on the beams abaft the foremast, and is therefore called the fore-knight; and the other, standing abaft the mainmast, is called the main-knight.

KNOXIA, a genus of the class and order tetrandria monogynia. The corolla is one-petalled, funnel-form; seeds two-grooved. There is one species, a herb of Ceylon.

KOENIGIA, a genus of the trigynia order, belonging to the triandria class of plants. The calyx is triphyllous; there is no corolla, and but one ovate and naked seed.

KORAN. See ALCORAN.

KUPFERNICKEL, is a sulphuret of nickel, and is generally compounded of nickel, arsenic, and sulphuret of iron.

KURTUS, a genus of fishes of the order jugulares; the generic character of which is, body broad, carinated both above and below, with greatly elevated back; gill-membrane two-rayed. The genus kurtus, instituted by Dr. Bloch, consists at present of a single species only. This is a native of the Indian seas; and is supposed to feed on shell-fish, small cancri, and other sea insects, the remains of which were observed in the stomach of the specimen examined by Dr. Bloch. The length of this fish was about ten inches, including the tail, and its greatest breadth something more than four inches; its shape is deep or broad, the sides being much compressed, and the back rising very high in the middle. The colour of the whole body is silvery, as if covered with foil, without any appearance of scales; the back is tinged with gold-colour and marked by three or four black spots on its ridge, and the fins have a reddish cast.

L.

L, or l, the eleventh letter of our alphabet, as a numeral, denotes 50; and with a line over it, thus, $\overline{L}$, 50000.

LA, in music, the syllable by which Guido denoted the last sound of each hexachord: if it begins in C, it answers to our A; if in G to E; and if in F to D.

LABARUM, in Roman antiquity, the standard borne before the Roman emperors: being a rich purple streamer, supported by a spear.

LABDANUM, or LADANUM. This resin is obtained from the cystus creticus, a shrub which grows in Syria and the Grecian islands. The surface of the shrub is covered with a viscid juice, which when concreted forms ladanum. It is collected while moist by drawing over it a kind of rake with thongs fixed to it; from these it is afterwards scraped with a knife. The best is in masses almost black, and very soft, having a fragrant odour and a bitterish taste. When dissolved in alcohol, it leaves behind it a little gum. The specific gravity of this resin is about 1.18. See RESINS.

LABEL, in heraldry, a fillet usually placed in the middle along the chief of the coat, without touching its exremities.

LABEL of a circumferentor, a long thin brass ruler, with a sight at one end, and a centre-hole at the other; chiefly used with a tangent line to take altitudes.

LABORATORY and *Apparatus*, chemical. A chemical laboratory, though extremely useful, and even essential to all who embark extensively in the practice of chemistry, either as an art, or as a branch of liberal knowledge, is by no means required for the performance of those simple experiments which furnish the evidence of the fundamental truths of the science. A room that is well lighted, easily ventilated, and destitute of any valuable furniture, is all that is absolutely necessary for the purpose. It is even advisable that the construction of a regular laboratory should be deferred till the student has made some progress in the science; for he will then be better qualified to accommodate its plan to his own peculiar views and convenience.

It is scarcely possible to offer the plan of a laboratory, which will be suitable to every person, and to all situations; or to suggest any thing more than a few rules that should be generally observed. Different apartments are required for the various classes of chemical operations. The principal one may be on the ground floor; twenty-five feet long, fourteen or sixteen feet wide, and open to the roof, in which there should be contrivances for allowing the occasional escape of suffocating vapours. This will be destined chiefly for containing furnaces, both fixed and portable. It should be amply furnished with shelves and drawers, and with a large table in the centre, the best form of which is that of a double cross. Another apartment may be appropriated to the minuter operations of chemistry; such as those of precipitation on a small scale, the processes that require

merely the heat of a lamp, and experiments on the gases. In a third, of smaller size, may be deposited accurate balances, and other instruments of considerable nicety, which would be injured by the acid fumes that are constantly spread through a laboratory.

The following are the principal instruments that are required in chemical investigations; but it is impossible, without entering into very tedious details, to enumerate all that should be in the possession of a practical chemist.

1. Furnaces. These may either be formed of solid brick-work, or of such materials as admit of their removal from place to place. See FURNACE, and CHEMISTRY.

2. For containing the materials, which are to be submitted to the action of heat in a wind furnace, vessels called crucibles are employed. They are most commonly made of a mixture of fire-clay and sand, occasionally with the addition of plumbago, or black lead. The Hessian crucibles are best adapted for supporting an intense heat without melting; but they are liable to crack when suddenly heated or cooled. The porcelain ones made by Messrs. Wedgewood, are of much purer materials, but are still more apt to crack on sudden changes of temperature; and when used, they should therefore be placed in a common crucible of larger size, the interval being filled with sand. The black-lead crucibles resist very sudden changes of temperature, and may be repeatedly used; but they are destroyed when some saline substances (such as nitre) are melted in them, and are consumed by a current of air. For certain purposes crucibles are formed of pure silver or platina. Their form varies considerably; but it is necessary, in all cases, to raise them from the bars of the grate, by a stand. For the purpose of submitting substances to the continued action of a red heat, and with a considerable surface exposed to the air, a hollow arched vessel, with a flat bottom, termed a muffle, is commonly used. See CHEMISTRY.

3. Evaporating vessels should always be of a flat shape, so as to expose them extensively to the action of heat. They are formed of glass, or earthenware, and of various metals. Those of glass are with difficulty made sufficiently thin, and are often broken by changes of temperature; but they have a great advantage in the smoothness of their surface, and in resisting the action of most acid and corrosive substances. Evaporating vessels of porcelain, or Wedgewood's ware, are next in utility, are less costly, and less liable to be cracked. They are made both of glazed and unglazed ware. For ordinary purposes, the former are to be preferred: but the unglazed should be employed when great accuracy is required, since the glazing is acted on by several chemical substances. Evaporating vessels of glass, or porcelain, are generally bedded up to their edge in sand; but those of various metals are placed immediately over the naked fire. When the glass or porcelain vessel is very thin, and of small size, it may be safely placed on the ring of a brass stand, and the flame of Argand's lamp, cautiously regulated, may be applied beneath it. A lamp thus supported, so as to be raised or lowered at pleasure, on an upright pillar, to which rings of various diameters are adapted, will be found extremely useful; and when a strong heat is required, it is advisable to employ a lamp provided with double concentric wicks.

4. In the process of evaporation, the vapour for the most part is allowed to escape; but in certain chemical processes, the collection of the volatile portion is the principal object. This process is termed distillation. See DISTILLATION.

The common still, however, can only be employed for volatilizing substances that do not act on copper, or other metals, and is, therefore, limited to very few operations, and on that account alembics and retorts are necessary. See CHEMISTRY.

In several instances, the substance raised by distillation, is partly a condensible liquid, and partly a gas, which is not condensed till it is brought into contact with water. To effect this double purpose, a series of receivers termed Woulfe's apparatus is employed. See CHEMISTRY.

When a volatile substance is submitted to distillation, it is necessary to prevent the escape of the vapour through the junctures of the vessels; and this is accomplished by the application of lutes. The most simple method of confining the vapour, it is obvious, would be to connect the places of juncture accurately together by grinding; and accordingly the neck of the retort is sometimes ground to the mouth of the receiver. This, however, adds too much to the expense of apparatus to be generally practised.

When the distilled liquid has no corrosive property, (such as water, alcohol, ether, &c.) slips of moistened bladder, or of paper or linen spread with flour paste, white of egg, or mucilage of gum Arabic, sufficiently answer the purpose. The substance which remains, after expressing the oil from bitter almonds, and which is sold under the name of almond meal or flour, forms a useful lute, when mixed to the consistency of glaziers' putty, with water or mucilage.

For confining the vapour of acid or highly corrosive substances, the fat lute is well adapted. It is formed by beating perfectly dry and finely sifted tobacco-pipe clay with painters' drying-oil, to such a consistence that it may be moulded by the hand. The same clay, beaten up with as much sand as it will bear without losing its tenacity, with the addition of cut tow, or of horse-dung, and a proper quantity of water, furnishes a good lute, which has the advantage of resisting a considerable heat, and is applicable in cases where the fat lute would be melted or destroyed. Various other lutes are recommended by chemical writers; but the few that have been enumerated are found to be amply sufficient for every purpose. See LUTE.

On some occasions, it is necessary to protect the retort from too sudden changes of temperature by a proper coating. For glass retorts, a mixture of common clay or loam with sand, and cut shreds of flax, may be employed. If the distillation is performed by a sand heat, the coating needs not to be applied higher than that part of the retort which is bedded in sand; but if the process is performed in a wind furnace, the whole body of the retort, and that part of the neck also which is exposed to heat, must be carefully coated. To this kind of distillation, however, earthen retorts are better adapted; and they may be covered with a composition originally recommended by Mr. Willis. Two ounces of borax are to be dissolved in a pint of boiling water, and a sufficient quantity of slaked lime added to give it the thickness of

cream. This is to be applied by a painter's brush, and allowed to dry. Over this a thin paste is afterwards to be applied, formed of slaked lime and common linseed-oil, well mixed and perfectly plastic. In a day or two, the coating will be sufficiently dry to allow the use of the retort.

For joining together the parts of iron vessels used in distillation, a mixture of the finest China clay, with solution of borax, is well adapted. In all cases, the different parts of any apparatus made of iron should be accurately fitted by boring and grinding, and the above lute is to be applied to the part which is received into an aperture. This will generally be sufficient without any exterior luting; otherwise the lute of clay, sand, and flax, already described, may be used.

In every instance, where a lute or coating is applied, it is advisable to allow it to dry before the distillation is begun; and even the fat lute, by exposure to the air during one or two days after its application, is much improved in its quality. The clay and sand lute is perfectly useless, except it is previously quite dry. In applying a lute, the part immediately over the juncture should swell outwards, and its diameter should be gradually diminished on each side.

Besides the apparatus already described, a variety of vessels and instruments are necessary, having little resemblance to each other in the purposes to which they are adapted. Glass vessels are required for effecting solution, which often requires the application of heat, and sometimes for a considerable duration. In the latter case it is termed digestion, and the vessel called a mattrass is the most proper for performing it. When solution is quickly effected, a bottle, with a rounded bottom, may be used, or a common Florence-oil flask serves the same purpose extremely well, and bears without cracking, sudden changes of temperature. Glass rods, of various length, and spoons of the same material, or of porcelain, are useful for stirring acid and corrosive liquids; and a stock of cylindrical tubes of various sizes, is required for occasional purposes. It is necessary also to be provided with a series of glass measures, graduated into drachms, ounces, and pints.

Accurate beams and scales, of various sizes, with corresponding weights, some of which are capable of weighing several pounds, while the smaller size ascertain a minute fraction of a grain, are essential instruments in the chemical laboratory. So also are mortars of different materials, such as of glass, porcelain, agate, and metal. Wooden stands of various kinds for supporting receivers, should be provided. For purposes of this sort, and for occasionally raising to a proper height any article of apparatus, a series of blocks, made of well-seasoned wood, eight inches (or any other number) square, and respectively eight, four, two, one, and half an inch in thickness, will be found extremely useful; since by combining them in different ways, no less than thirty-one different heights may be attained.

The blowpipe is an instrument of much utility in chemical researches. A small one, invented by Mr. Pepys, with a flat cylindrical box for condensing the vapour of the breath, and for containing caps, to be occasionally applied with apertures of various sizes, is perhaps, the most commodious form. A blowpipe, which is supplied with air from a pair of double bellows, worked by the foot, may be applied to purposes that require both hands to be left at liberty, and will be found useful in blowing glass, and in bending tubes. The latter purpose, however, may be accomplished by holding them over an Argand's lamp with double wicks.

Laboratory, signifies also in military affairs, that place where all sorts of fire-works are prepared both for actual service, and for pleasure, viz. quick matches, fusees, portfires, grape-shot, case-shot, carcases, hand-grenades, cartridges, shells filled and fusees fixed, wads, &c.

LABRUS, a genus of fishes of the order thoracici: the generic character is, teeth strong and subacute: the grinders sometimes, as in the spari, convex and crowded; lips thick and doubled: rays of the dorsal fin, in some species, elongated into soft processes. Gill-covers unarmed and scaly.

Labrus hepatus, snout rather pointed: teeth small: palate furnished with a rough bone. Native of the Mediterranean, sometimes wandering into rivers. There are 41 species belonging to this genus, all of which are but imperfectly understood.

LABOURER. See Master and Servant.

LABYRINTH, in gardening, a winding mazy walk between hedges, through a wood or wilderness. The chief aim is to make the walks so perplexed and intricate, that a person may lose himself in them, and meet with as great a number of disappointments as possible. They are rarely to be meet with, except in great gardens; as Versailles, Hampton-court, &c.

LAC, an appellation given to several chemical preparations.

Lac. This resin exudes from the tree called the croton laciferum, when punctured by an insect. For the history of its formation, and the use to which it is applied by the insects, the reader is referred to the article Gum, &c. It is a substance of a deep-red colour verging on brown, and semitransparent, and distinguished by various names according to its purity. It possesses the properties of a resin, and is the basis of many varnishes, and of the finest kinds of sealing-wax.

Lac *sulphuris*, is obtained by precipitating sulphur, when in combination: it is composed of sulphur united to a little water.

LACHERNALIA, a genus of the class and order hexandria monogynia. The cor. is six-parted, three outer petals difform; caps. three-winged; cells many-seeded; seeds globular, affixed to the recept. There are twelve species, chiefly bulbs of the Cape.

LACTATS, in chemistry, a genus of salts but little known. 1. Lactat of potass, a deliquescent salt soluble in alcohol. 2. Lactat of soda. This salt does not crystallize. It is soluble in alcohol. 3. Lactat of ammonia. Crystals which deliquesce. Heat separates a great part of the ammonia before destroying the acid. 4. Lactat of barytes; lime; alumina; all deliquesce.

LACCIC acid. About the year 1786, Dr. Anderson of Madras mentioned, in a letter to the governor and council of that place, that nests of insects, resembling small cowry shells, had been brought to him from the woods by the natives, who ate them with avidity. These supposed nests he soon afterwards discovered to be the

coverings of the females of an undescribed species of coccus, which he shortly found means to propogate with great facility on several of the trees and shrubs growing in his neighbourhood.

On examining this substance, which he called white lac, he observed in it a very considerable resemblance to bees' wax; he noticed also, that the animal which secretes it provides itself by some means or other with a small quantity of honey, resembling that produced by our bees; and in one of his letters he complains, that the children whom he employed to gather it were tempted by its sweetness to eat so much of it, as materially to reduce the produce of his crop. Small quantities of this matter were sent into Europe in 1789, both in its natural state and melted into cakes; and in 1793 Dr. Pearson, at the request of sir Joseph Banks, undertook a chemical examination of its qualities, and his experiments were published in the Philosophical Transactions for 1794.

A piece of white lac, from 3 to 15 grains in weight, is probably produced by each insect. These pieces are of a grey colour, opaque, rough, and roundish. When white lac was purified by being strained through muslin, it was of a brown colour, brittle, hard, and had a bitterish taste. It melted in alcohol, and in water of the temperature of 145°. In many of its properties it resembles bees' wax, through it differs in others; and Dr. Pearson supposes that both substances are composed of the same ingredients, but in different proportions.

1. Two thousand grains of white lac were exposed in such a degree of heat as was just sufficient to melt them. As they grew soft and fluid, there oozed out 550 grains of a reddish watery liquid, which smelled like newly baken bread. To this liquid Dr. Pearson has given the name of laccic acid.

2. It possesses the following properties:

It turns paper stained with turnsole to a red colour.

After being filtered, it has a slightly saltish taste with bitterness, but it is not at all sour.

When heated, it smells precisely like newly baken hot bread.

On standing, it grows somewhat turbid, and deposits a small quantity of sediment.

Its specific gravity at the temperature of 60° is 1.025.

A little of it having been evaporated till it grew very turbid, afforded on standing small needle-shaped crystals in mucilaginous matter.

Two hundred and fifty grains of it were poured into a very small retort and distilled. As the liquor grew warm, mucilage-like clouds appeared; but as the heat increased they disappeared again. At the temperature of 200° the liquor distilled over very fast: a small quantity of extractive matter remained behind. The distilled liquor while hot smelled like newly baken bread, and was perfectly transparent and yellowish. A shred of paper stained with turnsole, which had been put into the receiver, was not reddened; nor did another which had been immersed in a solution of sulphat of iron, and also placed in the receiver, turn to a blue colour upon being moistened with the solution of potass.

About 100 grains of this distilled liquid being evaporated till it grew turbid, after being set by for a night, afforded acicular crystals, which under a lens appeared in a group not unlike the umbel of parsley. The whole of them did not amount to the quarter of a grain. They tasted only bitterish.

Another 100 grains being evaporated to dryness in a very low temperature, a blackish matter was left behind, which did not entirely disappear on heating the spoon containing it very hot in the naked fire; but on heating oxalic acid to a much less degree, it evaporated and left not a trace behind.

Carbonat of lime dissolved in this distilled liquid with effervescence. The solution tasted bitterish, did not turn paper stained with turnsole red, and on adding to it carbonat of potass a copious precipitation ensued. A little of this solution of lime and of alkali being evaporated to dryness, and the residuum made red-hot, nothing remained but carbonate of lime, and carbonat of potass.

This liquid did not render nitrat of lime turbid, but it produced turbidness in nitrat and muriat of barytes.

To 500 grains of the reddish-coloured liquor obtained by melting white lac, carbonat of soda was added till the effervescence ceased, and the mixture was nutralized; for which purpose three grains of the carbonat were necessary. During this combination a quantity of mucilaginous matter, with little carbonate of lime, was precipitated. The saturated solution being filtrated and evaporated to the due degree, afforded on standing deliquescent crystals, which on exposure to fire, left only a residum of carbonat of soda.

Lime-water being added to this reddish-coloured liquor produced a light purple turbid appearance; and on standing there were clouds just perceptible.

Sulphuret of lime occasioned a white precipitation, but no sulphureted hydrogen gas was preceptible by the smell.

Tincture of galls produced a green precipitation.

Sulphat of iron produced a purplish colour, but no precipitation; nor was any precipitate formed by the addition first of a little vinegar and then of a little potass to the mixture.

Acetat of lead occasioned a reddish precipitation, which redissolved on adding a little nitric acid.

Nitrat of mercury produced a whitish turbid liquor.

Oxalic acid produced immediately the precipitation of white acicular crystals owing probably to the presence of a little lime in the liquid.

Tartrat of potass produced a precipitation not unlike what takes place on adding tartaric acid to tartrat of potass; but it did not dissolve again on adding potass.

LACE, in commerce, a work composed of many threads of gold, silver, or silk, interwoven one with the other, and worked upon a pillow with spindles, according to the pattern designed; the open work being formed with pins, which are placed and displaced as the spindles are moved.

Method of cleaning gold-lace and embroidery when tarnished.—For this purpose alkaline liquors are by no means to be used; for while they clean the gold they corrode the silk, and change or discharge its colour. Soap also alters the shade, and even the species of certain colours. But spirit of wine may be used without any danger of its injuring either the colour or quality of the subject; and in many cases proves as effectual for restoring the lustre of the gold as the corrosive detergents.

But though spirit of wine is the most innocent materi-

al that can be employed for this purpose, it is not in all cases proper. The golden covering may be in some parts worn off; or the base metal, with which it has been iniquitously alloyed, may be corroded by the air, so as to leave the particles of the gold disunited; while the silver underneath, tarnished to a yellow hue, may continue a tolerable colour to the whole: in which cases it is apparent that the removal of the tarnish would be prejudicial to the colour, and make the lace or embroidery less like gold than it was before.

Lace, *bone*, a lace made of fine linen thread or silk, much in the same manner as that of gold and silver. The pattern of the lace is fixed upon a large round pillow, and pins being stuck into the holes or openings in the pattern, the threads are interwoven by means of a number of bobins, made of bone or ivory, each of which contains a small quantity of fine thread, in such a manner as to make the lace exactly resemble the pattern. There are several towns in England, and particularly in Buckinghamshire, that carry on this manufacture; but vast quantities of the finest laces have been imported from Flanders.

LACERTA, *lizard*, a genus of the amphibia class, and of the order of reptiles: the generic character is, body four-footed, elongated, tailed; without any secondary integument.

This numerous genus may be divided into the following sections, viz.

1. Crocodiles, furnished with very strong scales.
2. Guanas, and other lizards, either with serrated or carinated backs and tails.
3. Cordyles, with denticulated, and sometimes spiny scales, either on the body or tail, or both.
4. Lizards proper, smooth, and the greater number furnished with broad square scales or plates on the abdomen.
5. Chamæleons, with granulated skin, large head, long missile tongue, and cylindric tail.
6. Geckos, with granulated or tuberculated skin, and lobated feet, with the toes lamellated beneath.
7. Scinks, with smooth, fish-like, scales.
8. Salamanders, newts, or efts, with soft skins, and of which some are water-lizards.
9. Snake-lizards, with extremely long bodies, very short legs, and minute feet.

The above divisions neither are, nor can be, perfectly precise; since species may occur which may, with almost equal propriety, be referred to either of the neighbouring sections; but, in general, they will be found useful in the investigation of the species. The following are the most noted:

1. Lacerta crocodilus, or crocodile. The crocodile, so remarkable for its size and powers of destruction, has in all ages been regarded as one of the most formidable animals of the warmer regions. It is a native of Asia and Africa, but seems to be most common in the latter; inhabiting large rivers, as the Nile (see Plate LXXIV. Nat. Hist. fig. 237), the Niger, &c. and preying principally on fish, but occasionally seizing on almost every animal which happens to be exposed to its rapacity. The size to which the crocodile sometimes arrives is prodigious; specimens being frequently seen of 20 feet in length, and instances are commemorated of some which have exceeded the length of 30 feet. The armour with which the upper part of the body is covered may be numbered among the most elaborate pieces of nature's mechanism. In the full-grown animal it is so strong and thick as easily to repel a musket-ball; on the lower parts it is much thinner, and of a more pliable nature: the whole animal appears as if covered with the most regular and curious carved work: the colour of a full-grown crocodile is blackish-brown above, and yellowish-white beneath; the upper parts of the legs and the sides varied with deep yellow, and in some parts tinged with green. In the younger animals the colour on the upper parts is a mixture of brown and pale yellow, the under parts being nearly white: the eyes are provided with a nictitating membrane, or transparent moveable pellicle, as in birds: the mouth is of vast width, the rictus or gape having a somewhat fluxuous outline, and both jaws being furnished with very numerous sharp-pointed teeth, of which those about the middle part of each jaw considerably exceed the rest in size, and seem analogous to the canine teeth in the viviparous quadrupeds or mammalia: the number of teeth in each jaw is 30, or more; and they are so disposed as to alternate with each other when the mouth is closed: on taking out the teeth and examining the alveoli, it has been found that small teeth were forming beneath, in order to supply the loss of the others when shed: the auditory foramina are situated on the top of the head, above the eyes, and are moderately large, oval, covered by a membrane, having a longitudinal slit or opening, and thus in some degree resembling a pair of closed eyes: the legs are short, but strong and muscular: the fore feet have five toes, and are unwebbed: the hind feet have only four toes, which are united towards their base by a strong web: the two interior toes on each of the fore feet, and the interior one of the hind feet, are destitute of claws: on the other toes are strong, short, and curved claws: the tail is very long, of a laterally compressed form, and furnished above with an upright process, formed by the gradual approximation of two elevated crests proceeding from the lower part of the back.

The crocodile in a young state is by no means to be dreaded, its small size and weakness preventing it from being able to injure any of the larger animals: it therefore contents itself with fish and other small prey; and such as have occasionally been brought to Europe are so far from being formidable or ferocious, that they may be generally handled with impunity, and either from weakness, or the effect of a cold climate, seem much inclined to torpidity; but in the glowing regions of Africa, where it arrives at its full strength and power, it is justly regarded as the most formidable inhabitant of the rivers. It lies in wait near the banks, and snatches dogs and other animals, swallowing them instantly, and then plunging into the flood, and seeking some retired part, where it may lie concealed till hunger again invites it to its prey. In its manner of attack it is exactly imitated by the common lacerta palustris, or water-newt, which, though not more than four or five inches long, will with the greatest ease swallow an insect of more than an inch in length; and that at one single effort, and with a motion so quick, that the eye can scarcely follow it. It poises itself in the water, and having gained a convenient distance, springs with the utmost celerity on the insect, and

swallows it. If, therefore, a small lizard of four or five inches only in length can thus instantaneously swallow an animal of a fourth part of its own length, we need not wonder that a crocodile of 18, 20, or 25, feet long, should suddenly ingorge a dog or other quadruped.

Crocodiles, like the rest of the lacertæ, are oviparous: they deposit their eggs in the sand or mud near or on the banks of the rivers they frequent, and the young when hatched immediately proceed to the water; but the major part are said to be commonly devoured by other animals, as ichneumons, birds, &c. The egg of the common nilotic crocodile is not much larger than that of a goose, and in external appearance bears a most perfect resemblance to that of a bird; being covered with a calcareous shell, under which is a membrane. When the young are first excluded the head bears a much larger proportion to the body than when full-grown. The eggs, as well as the flesh of the crocodile itself, are numbered among the delicacies of some of the African nations, and are said to form one of their favourite repasts.

In the large rivers of Africa crocodiles are said to be seen swimming together in vast shoals, and resembling the trunks of so many large trees floating on the water. The negroes will sometimes attack and kill a single crocodile, by stabbing it under the belly, where the skin, at the interstices of the scales; is soft and flexible. It is also, in some countries, the custom to hunt the crocodile by means of strong dogs, properly trained to the purpose, and armed with spiked collars. It is likewise pretended, that in some parts of Africa crocodiles are occasionally tamed; and it is said that they form an article of royal magnificence with the monarchs of those regions, being kept in large ponds or lakes appropriated to their residence. We may add, that the ancient Romans exhibited these animals in their public spectacles and triumphs. Scaurus, during his ædileship, treated the people with a sight of five crocodiles, exhibited in a temporary lake; and Augustus introduced one into his triumph over Cleopatra, as well as several others, for the entertainment of the people.

2. Lacerta alligator. So very great is the general resemblance between this animal and the crocodile, that many naturalists have been strongly inclined to consider it as a mere variety, rather than a distinct species. The more accurate discrimination, however, of Blumenbach and some others seems in reality to prove that the alligator or American crocodile is specifically distinct from the nilotic, though the difference is not such as immediately to strike a general observer. The leading difference, if it be allowed to constitute a distinction of species, seems to be, that the head of the alligator is rather smooth on the upper part than marked with those very strong rugosities and hard carinated scales which appear on that of the crocodile; and that the snout is considerably flatter and wider, as well as more rounded at the extremity. The alligator arrives at a size not much inferior to that of the crocodile, specimens having been often seen of 18 or 20 feet in length.

"Though the largest and greatest numbers of alligators," says Catesby, "inhabit the torrid zone, the continent abounds with them 10 degrees more north, particularly as far as the river Neus in North Carolina, in the latitude of about 33 degrees, beyond which I have never heard of any, which latitude nearly answers to the northernmost parts of Africa, where they are likewise found. They frequent not only salt rivers near the sea, but streams of fresh water in the upper parts of the country, and in lakes of salt and fresh water, on the banks of which they lie lurking among reeds, to surprise cattle and other animals. In Jamaica, and many parts of the continent, they are found about 20 feet in length: they cannot be more terrible in their aspect than they are formidable and mischievous in their natures, sparing neither man nor beast they can surprise, pulling them down under water, that being dead, they may with greater facility, and without struggle or resistance, devour them. As quadrupeds do not so often come in their way, they almost subsist on fish; but as Providence, for the preservation, or to prevent the extinction of defenceless creatures, has in many instances restrained the devouring appetites of voracious animals, by some impediment or other, so this destructive monster, by the close connexion of his vertebræ, can neither swim nor run any other way than straight forward, and is consequently disabled from turning with that agility requisite to catch his prey by pursuit: therefore they do it by surprise in the water as well as by land; for effecting which nature seems in some measure to have recompensed their want of agility, by giving them a power of deceiving and catching their prey by a sagacity peculiar to them, as well as by the outer form and colour of their body, which on land resembles an old dirty log or tree, and in the water frequently lies floating on the surface, and there has the like appearance, by which, and his silent artifice, fish, fowl, turtle, and all other animals, are deceived, suddenly catched, and devoured.

"In Carolina they lie torpid from about October to March, in caverns and hollows in the banks of rivers, and at their coming out in the spring make an hideous bellowing noise. The hind part of their belly and tail are eaten by the Indians. The flesh is delicately white, but has so perfumed a taste and smell that I never could relish it with pleasure."

3. Lacerta gangetica. The gangetic crocodile is so strikingly distinguished both from the nilotic and the aligator by the peculiar form of the mouth, that it is hardly possible, even on a cursory view, to confound it with either of the former; the jaws being remarkably long, narrow, and perfectly straight, and the upper mandible terminated above an elevated tubercle. In a very young state the length and narrowness of the snout are still more conspicuous than the full-grown animal. The teeth are nearly double the number of those of the common crocodile, and are of equal size throughout the whole length of the jaws. This species is a native of India, and is principally seen in the Ganges, where it arrives at a size at least equal to the nilotic crocodile.

4. Lacerta iguana. Though the lizard tribe affords numerous examples of strange and peculiar form, yet few species are perhaps more eminent in this respect than the guana, which grows to a very considerable size, and is often seen of the length of three, four, and even five feet. It is a native of many parts of America and the West Indian islands, and is also said to occur in some parts of the East Indies. Its general colour is green, but with much variation in the tinge of different individuals:

it is generally shaded with brown in some parts of the body, and sometimes this is the predominating colour. The back of the guana is very strongly serrated; and this, together with the gular pouch, which it has the power of extending or inflating occasionally to a great degree. gives a formidable appearance to an animal otherwise harmless. It inhabits rocky and woody places, and feeds on insects and vegetables. It is itself reckoned an excellent food, being extremely nourishing and delicate; but it is observed to disagree with some constitutions. The common method of catching it is by casting a noose over its head, and thus drawing it from its situation; for it seldom makes an effort to escape, but stands looking intently at its discoverer, inflating its throat at the same time in an extraordinary manner.

The guana may be easily tamed while young, and is both an innocent and beautiful creature in that state.

5. Lacerta basiliscus. The basilisk of the ancients, supposed to be the most malignant of all poisonous animals, and of which the very aspect was said to be fatal, is a fabulous existence, to be found only in the representations of painters and poets.

But the animal known in modern natural history by this name is a species of lizard, of a very singular shape, and which is particularly distinguished by a long and broad wing-like process or expansion continued along the whole length of the back, and to a very considerable distance on the upper part of the tail, and furnished at certain distances with internal radii analogous to those in the fins of the fishes, and still more so to those in the wings of the draco volans, or flying lizard. This process is of a different elevation in different parts, so as to appear strongly sinuated and indented, and is capable of being either dilated or contracted at the pleasure of the animal. The occiput or hind part of the head is elevated into a very conspicuous pointed hood or hollow crest.

Notwithstanding its formidable appearance the basilisk is a perfectly harmless animal, and, like many other of the lizard tribe, resides principally among trees, where it feeds on insects, &c. The colour of the basilisk is a pale cinereous brown, with some darker variegations towards the upper part of the body. It is principally found in South America, and sometimes considerably exceeds the length before mentioned, measuring three feet, or even more, from the nose to the extremity of the tail. It is said to be an animal of great agility, and is capable of swimming occasionally with perfect ease, as well as of springing from tree to tree by the help of its dorsal crest, which it expands in order to support its flight.

6. Lacerta calotes. This species is considerably allied to the common guana in habit or general appearance; but is of much smaller size, rarely exceeding the length of a foot and a half from the tip of the nose to the extremity of the tail. It is also destitute of the very large gular pouch, so conspicuous in that animal; instead of which it has merely a slight inflation or enlargement on that part. In colour it occasionally varies, like most of this tribe; but it is commonly of an elegant bright blue, variegated by several broad, and somewhat irregular white or whitish transverse bands on each side of the body and tail. It is a native of the warmer regions both of Asia and Africa, and is found in many of the Indian islands, and particularly in Ceylon, in which it is common. According to the count de Cepede it is also found in Spain, &c. and is said by that author to wander about the top of houses in quest of spiders; and he observes, that it is even reported to prey on rats, and to fight with small serpents in the manner of the common green lizard and some others. See Plate LXXIV. Nat. Hist. fig. 256.

7. Lacerta monitor. The monitor, or monitory lizard, is one of the most beautiful of the whole tribe, and is also one of the largest; sometimes measuring not less than four or five feet from the nose to the tip of the tail. Its shape is slender and elegant, the head being small, the snout gradually tapering, the limbs moderately slender, the tail laterally compressed, and insensibly decreasing towards the tip, which is very slender and sharp. Though the colours of this lizard are simple, yet such is their disposition, that it is impossible to survey their general effect without admiration. In this respect, however, the animal varies perhaps more than most others of its tribe. It is commonly black, with the abdomen white, the latter colour extending to some distance up the sides, in the form of several pointed bands, besides which the whole body is generally ornamented by several transverse bands consisting of white annular spots, while the head is marked with various streaks of the same colour, the limbs with very numerous round spots, and the tail with broad, distant, transverse bands. It is a native of South America, where it frequents woody and watery places; and, if credit may be given to the reports of some authors, is of a disposition as gentle as its appearance is beautiful. It has even gained the title of monitor, salvaguarda, &c, from its pretended attachment to the human race, and it has been said that it warns mankind of the approach of the aligator by a loud and shrill whistle.

Cordyles, with either denticulated or spiny scales on the body or tail, or both.

8. Lacerta pelluma, is one of the middle sized lizards; the total length being nearly two feet, and the length of the body and tail nearly equal. It is a native of Chili, where it is said to inhabit hollows under ground. It is covered on the upper parts with very minute scales, and is beautifully variegated with green, yellow, blue, and black: the under parts are of a glossy yellowish-green: the tail long and verticillated by rows of rhomboidal scales. The skin of this lizard is said to be used by the Chilians for the purpose of a purse.

9. Lacerta stellio, is remarkable for the usually rough or hispid appearance of its whole upper surface; both body, limbs, and tail, being covered with pointed scales, projecting here and there to a considerable distance beyond the surface, so that it appears muricated with spines: the tail is rather short than long, and is verticillated with rows of pointed scales. The general colour of the animal is a pale blueish-brown, with a few deeper and lighter transverse variegations: its general length is about eight inches. It is a native of many parts of Africa.

Lizards proper, smooth, and the greater number furnished with broad square plates or scales on the abdomen.

10. Lacerta agilis, green lizard, is found in all the warmer parts of Europe, and seems pretty generally diffused over the ancient continent. It sometimes arrives at a very considerable size, measuring more than two feet to the extremity of the tail: its more general

length, however, is from 10 to 15 inches. In its colours it is the most beautiful of all the European lacertæ, exhibiting a rich and varied mixture of darker and lighter green, interspersed with specks and marks of yellow, brown, blackish, and even sometimes red. The green lizard is found in various situations, in gardens, about warm walls, buildings, &c. and is an extremely active animal, pursuing with great celerity its insect prey, and escaping with great readiness from pursuit when disturbed. If taken, however, it is soon observed to become familiar, and may even be tamed to a certain degree; for which reason it is considered as a favourite animal in many of the warmer parts of Europe. It appears to run into numerous varieties both as to size and colour; but in all these states the particular characteristics of the species are easily ascertained.

11. Lacerta bullaris, red-throat lizard. This, according to Catesby, is usually six inches long, and of a shining grass-green colour. It is common in Jamaica, frequenting hedges and trees, but is not seen in houses: when approached it swells its throat into a globular form, the protruded skin on that part appearing of a bright-red colour, which disappears in its withdrawn or contracted state: this action is supposed to be a kind of menace, in order to deter its enemy; but it is incapable of doing any mischief by its bite or otherwise. See Plate LXXIV. Nat. Hist. fig. 235.

Chameleons, with granulated skin, missile tongue, &c.

12. Lacerta chamæleon. Few animals have been more celebrated by natural historians than the chameleon, which has been sometimes said to possess the power of changing its colour at pleasure, and of assimilating it to that of any particular object or situation. This, however, must be received with very great limitations; the change of colour which the animal exhibits varying in degree according to circumstances of health, temperature of the weather, and many other causes, and consisting chiefly in a sort of alteration of shades from the natural greenish or bluish grey of the skin into pale yellowish, with irregular spots or patches of dull red.

It is also to be observed, that the natural or usual colour of chameleons varies very considerably; some being much darker than others, and it has even been seen approaching to a blackish tinge. And occasional change of colour is likewise observable, though in a less striking degree, in some other lizards.

The general length of the chameleon, from the tip of the nose to the beginning of the tail, is about ten inches, and the tail is of nearly similar length, but the animal is found of various sizes, and sometimes exceeds the length above mentioned. It is a creature of a harmless nature, and supports itself by feeding on insects; for which purpose the structure of the tongue is finely adapted, consisting of a long, missile body, furnished with a dilated and somewhat tubular tip, by means of which the animal seizes insects with great ease, darting out its tongue in the manner of a woodpecker, and retracting it instantaneously with the prey secured on its tip. It can also support a long abstinence, and hence arose the popular idea of the chameleon being nourished by air alone. It is found in many parts of the world, and particularly in India and Africa. It is also sometimes seen in the warmer parts of Spain and Portugal.

The general or usual changes of colour in the chameleon, are from a bluish ash-colour, (its natural tinge) to a green and sometimes yellowish colour, spotted unequally with red. If the animal is exposed to a full sunshine, the unilluminated side generally appears, within the space of some minutes, of a pale yellow, with large roundish patches or spots of red-brown. On reversing the situation of the animal, the same change takes place in an opposite direction; the side which was before in the shade now becoming either brown or ash-colour, while the other side becomes yellow and red; but these changes are subject to much variety both as to intensity of colours and disposition of spots.

Besides the common chameleon, different races appear to exist, which are principally distinguished by their colour, and the more or less elevated state of the angular or crested part of the head. These, which Linnæus was content to consider as varieties, are now raised to the dignity of species, and are so distinguished in the Gmelinian edition of the Systema Naturæ.

Geckos, with granulated or tuberculated skin, lobated feet, and toes lamellated beneath.

13. Lacerta gecko. The gecko, said to be so named from the sound of its voice, which resembles the above word uttered in a shrill tone, is a native of many parts of Asia and Africa, as well as of some of the warmer regions of Europe. It is one of the middle-sized lizards, measuring, in general, about a foot in length, or rather more. It is of a thicker and stouter form than most other lizards, having a large and somewhat triangular flattish head, covered with small scales, a wide mouth, large eyes, minute teeth, and a broad flat tongue. The limbs are of moderate length, and the feet are of a broader form than the rest of the genus.

The gecko inhabits obscure recesses, caverns, old walls, trees, &c. and wanders about chiefly on the approach of rain. It is considered as of a poisonous nature, a highly acrimonious kind of fluid exuding from the lamellæ of the feet, which remaining on the surface of fruit or any other edible substance is often productive of troublesome symptoms to those who happen to swallow it. From the peculiar structure of its feet, the gecko can readily adhere to the smoothest surfaces. The general colour of the animal is pale brown, with a few irregular dusky or bluish variegations; but in those which inhabit the warmer regions of the globe, this colour seems to be exalted into a much more brilliant appearance.

14. Lacerta fimbriata. This remarkable species seems to have been first described by the count de Cepede, who informs us that it appears in some degree to connect the chameleon, the gecko, and the water-newts; the head, skin, and general form of the body, resembling those of the chameleon; the tail that of the water-newts, being of a compressed form, though in a different manner (not vertically but horizontally flattened), while the feet resemble those of the gecko. The largest specimen examined by the count de Cepede measured about eight inches and six lines in length, of which the tail measured two inches and four lines.

The colour of this animal is not constant or permanent, as in most lizards, but variable, as in the chameleon, presenting successively different shades of red, yel-

low, green, and blue. This variation of colour is, however, confined to the upper surface of the animal; the lower always continuing of a bright yellow. The changes, we are informed, have been observed in the living animal by Mons. Bruyeres, in his native country, viz. Madagascar, where it is not very uncommon, and where, though a harmless animal, it is held in great abhorrence by the natives, who consider it as of a poisonous nature, and fly from it with precipitation; pretending that it darts on their breast, and adheres with such force by its fringed membrane, that it cannot be separated from the skin without the assistance of a razor. The principal cause of this popular dread of the animal, is its habit of running open-mouthed towards the spectator, instead of attempting to escape when discovered. Its chief residence is on the branches of trees, where it lives on insects, holding itself secure by coiling its tail, short as it is, half round the twig on which it sits. It chiefly appears in rainy weather, when it moves with considerable agility, often springing from bough to bough. On the ground it walks but slowly, the fore legs being shorter than the hinder.

Scinks, with round fish-like scales.

15. Lacerta scincus, or officinal scink. The scink is one of the middle-sized or smaller lizards, and is a native of many of the eastern parts of the world. It abounds in Lybia, Syria, Egypt, and Arabia, frequenting moderately dry and sandy soils, and growing to the length of six or seven inches, or even sometimes more. The head of the scink is rather small than large, the body thick and round, the tail in general considerably shorter than the body. The whole animal is of a pale yellowish-brown colour, with a few broad, dusky, transverse undulations or zones, and is uniformly covered with moderately large or fish-like scales, lying extremely close and smooth, so that the surface has a glossy or oily appearance. It is an animal of harmless manners, and, like most other lizards, supports itself on the various insects which wander about the regions it inhabits.

This animal was once in high estimation as an article in the materia medica, and the flesh, particularly of the belly, was supposed to be diuretic, alexipharmic, restorative, and useful in leprous and many other cases; but whatever virtues it may possess when used fresh, it is not considered as of any importance when in its dried or imported state, and while it continued to be used in practice served only to increase the number of ingredients in that curious remnant of what Dr. Lewis happily terms the wild exuberance of medical superstition in former ages, the celebrated confectio democratis, or mithridate.

Salamanders, Newts, or Efts.

16. Lacerta salamandra. The salamander, so long the subject of popular error, and of which so many idle tales have been recited by the more ancient naturalists, is an inhabitant of many parts of Germany, Italy, France, &c. but does not appear to have been discovered in England. It delights in moist and shady places, woods, &c. and is chiefly seen during a rainy season. In the winter it lies concealed in the hollows about the roots of old trees, in the subterraneous recesses, or in the cavities of old walls, &c. The salamander is easily distinguished by its colours; being of a deep shining black, variegated with large, oblong, and rather irregular patches of bright orange-yellow, which, on each side of the back, are commonly so disposed as to form a pair of interrupted longitudinal stripes: the sides are marked by many large transverse wrinkles, the intermediate spaces rising into strongly marked convexites; and the sides of the tail often exhibits a similar appearance: on each side of the back of the head are situated a pair of large tubercles, which are in reality the parotid glands: and are thus protuberant not only in some others of the lizard tribe, but in a remarkable manner in the genus rana: these parts, as well as the back and sides of the body, are beset in the salamander with several large open pores or foramina, through which exudes a peculiar fluid, serving to lubricate the skin, and which, on any irritation, is secreted in a more sudden and copious manner under the form of a whitish gluten, of a slightly acrimonious nature; and from the readiness with which the animal, when disturbed, appears to evacuate it, and that even occasionally to some distance, has arisen the long-continued popular error of the salamander's being enabled to live uninjured in the fire; which it has been supposed capable of extinguishing by its natural coldness and moisture: the real fact is, that like any of the cold and glutinous animals, as snails, &c. it, of course, is not quite so instantaneously destroyed by the force of fire as an animal of a drier nature would be. The general length of the salamander is about seven or eight inches, though it sometimes arrives at a much larger size. It is capable of living in water as well as on land, and is sometimes found in stagnant pools, &c. Its general pace is slow, and its manners torpid.

A strange error appears to have prevailed relative to the supposed poisonous nature of this animal; and the malignity of its venom has even been considered as scarcely admitting a remedy. It may be sufficient to observe, that the salamander is perfectly innoxious, and incapable of inflicting either wound or poison on any of the larger animals, though it appears, from the experiments of Laurenti, that the common small grey lizard (L. agil. var.) is poisoned by biting a salamander, and thus swallowing the secreted fluid of the skin; becoming almost immediately convulsed, and dying in a very short time afterwards.

The salamander is a viviparous species; producing its young perfectly formed, having been first hatched from internal eggs, as in the viper, and some other amphibia. It is said to retire to the water in order to deposit its young, which, at the first exclusion, are furnished with ramified branchial fins or processes on each side the neck, and which being merely temporary organs, are afterwards obliterated, as in the young of frogs and water-newts. The number of young produced at one birth by the salamander is said sometimes to amount to 30 or 40.

17. Lacerta vulgaris. This, which is the smallest of the British lizards, is altogether a terrestrial species. It is commonly seen in gardens, and not unfrequently in the neighbourhood of dunghills, &c. It also occasionally makes its way into cellars in the manner of the slug, the toad, &c.

18. Lacerta aquatica. This, which in England occurs

almost in every stagnant water, is a small species. Its general length is about three inches and a half, and it very rarely exceeds that of four inches at most.

The water-newts are remarkable for a high degree of reproductive power, and have been known to exhibit the restoration of their legs, tails, and even, according to Dr. Blumenbach, of the eyes themselves, after having been deprived of them by cutting.

Snake lizards, with extremely long bodies and short legs.

19. Lacerta chalcides. The chalcides is a native of many of the warmer parts of Europe, as well as of Africa, and is found of different sizes, from the length of a few inches to that of a foot, or even more. Its general length, however, seems to be eight or nine inches. The chalcides is an animal of a harmless nature, frequenting moist shady places, moving rather slowly, and feeding on insects, small worms, &c. It is a viviparous species, and is said to produce a great many young. The serpents to which it bears the nearest alliance in point of form, are those of the genus anguis, and particularly the A. fragilis, or common slow-worm.

20. Lacerta apus. A still nearer approach is made to the snake tribe by this large and singular lizard than even by the chalcides. It is a native of Greece, the southern parts of Siberia, and doubtless of many other parts of Europe and Asia, though it seems to have been but recently known to naturalists. It is found of the length of nearly three feet, and so perfectly resembles the general form of a large snake, that it is not without a near inspection that it is ascertained to belong to the race of lizards; being furnished merely with a pair of very short and somewbat acuminated processes by way of feet, situated at a vast distance from the fore parts of the body, nearly on each side the vent: the processes have no divisions or toes, but seem to form one simple projection, with a slight indenture only. The animal frequents moist and shady places, and appears to be of a harmless character.

LACHNEA, a genus of the monogynia order, in the octandria class of plants, and in the natural method ranking under the 31st order, veprecolæ. There is no calyx; the corolla is quadrifid, with the limb unequal; there is one seed a little resembling a berry. There are two species, shrubs of the Cape.

LACHRYMALIS, FISTULA. See SURGERY.

LACHRYMATORY, in antiquity, a vessel wherein were collected the tears of a deceased person's friends, and preserved along with the ashes and urn.

LACIS, a genus of the class and order polyandria digynia. There is no calyx or corolla. The filaments are winged on both sides below; the receptacle is girt with 12 spines; capsules ovate. There is one species, an aquatic of Guiana.

LACISTIMA, a genus of the monandria digynia class and order. The calyx is the scale of the ament; corolla four-parted; filaments bifid; berry pedicelled, one-seeded. There is one species, a shrub of Jamaica.

LACK OF RUPEES, is 100,000 rupees; which, supposing them standard, or siccas, at 2*s.* 6*d.* amounts to 12,500*l.* sterling.

LACQUERS, are varnishes applied upon tin, brass, and other metals, to preserve them from tarnishing, and to improve their colour. The basis of lacquers is a solution of the resinous substance called seed-lac in spirit of wine. The spirit ought to be very much concentrated, in order to dissolve much of the lac. For this purpose, some authors direct dry potass to be thrown into the spirit. This alkali attracts the water, with which it forms a liquid that subsides distinctly from the spirit at the bottom of the vessel. From this liquid the spirit may be separated by decantation. By this method the spirit is much concentrated; but, at the same time, it becomes impregnated with part of the alkali, which depraves its colour, and communicates a property to the lacquer of imbibing moisture from the air. These inconveniences may be prevented by distilling the spirit; or, if the artist has not an opportunity of performing that process, he may cleanse the spirit, in a great measure, from the alkali, by adding to it some calcined alum; the acid of which uniting with the alkali remaining in the spirit, forms with it a vitriolated tartar, which, not being soluble in spirit of wine, falls to the bottom together with the earth of the decomposed alum. To a pint of the purified spirit, about three ounces of powdered shell-lac are to be added; and the mixture to be digested during the same day with a moderate heat. The liquor ought then to be poured off, strained, and cleared by settling. This clear liquor is now fit to receive the required colour from certain resinous colouring substances, the principal of which are gamboge and annotto; the former of which gives a yellow, and the latter an orange colour. In order to give a golden colour, two parts of gamboge are added to one of annotto; but these colouring substances may be separately dissolved in the tincture of lac, and the colour required may be adjusted by mixing the two solutions in different proportions. When silver leaf or tin is to be lacquered, a larger quantity of the colouring materials is requisite than when the lacquer is intended to be laid on brass.

LACTEAL VESSELS. See ANATOMY.

LACTIC ACID. If milk be kept for some time it becomes sour. The acid which then appears in it was first examined by Scheele, and found by him to have peculiar properties. It is called lactic acid. In the whey of milk this acid is mixed with a little curd, some phosphat of lime, sugar of milk, and mucilage. All these must be separated before the acid can be examined. Scheele accomplished this by the following process:

Evaporate a quantity of sour whey to an eighth part, and then filtrate it: this separates the cheesy parts. Saturate the liquid with lime-water, and the phosphat of lime precipitates. Filtrate again, and dilute the liquid with three times its own bulk of water; then let fall into it oxalic acid, drop by drop, to precipitate the lime which it has dissolved from the lime-water; then add a very small quantity of lime-water, to see whether too much oxalic acid has been added. If there has, oxalat of lime immediately precipitates. Evaporate the solution to the consistence of honey, pour in a sufficient quantity of alcohohol, and filtrate again; the acid passes through dissolved in the alcohol, but the sugar of milk and every other substance remain behind. Add to the solution a small quantity of water, and distil with a small heat, the alcohol passes over, and leaves behind the lactic acid dissolved in water.

This acid is incapable of crystallizing: when evaporated to dryness, it deliquesces again in the air. When distilled, water comes over first, then a weak acid resembling the tartaric, then an empyreumatic oil mixed with more of the same acid, and, lastly, carbonic acid and carbureted hydrogen gas: there remains behind a small quantity of charcoal.

The combinations which this acid forms with alkalies, earths, and metallic oxides, are called lactats, which see.

All that is known concerning these salts are the following facts, ascertained by Scheele. When saturated with fixed alkalies, it gave salts which were deliquescent and soluble in spirit of wine. It formed deliquescent salts with ammonia, with barytes, with lime, and alumina; but with magnesia it formed small crystals, which however at length deliquesced. This acid had no effect on bismuth, cobalt, antimony, tin, mercury, silver, and gold. It dissolved zinc and iron; and it produced with these metals hydrogen gas. Zinc was the only metal with which it crystallized. Copper rendered this acid first slightly blue, then green, and lastly a deep blue; but no crystals were formed. Digested upon lead it became sweet, but did not crystallize.

LACTUCA, the *lettuce*, a genus of the polygamia æqualis order, in the syngenesia class of plants, and in the natural method ranking under the 49th order, compositæ. The receptacle is naked; the calyx imbricated, cylindrical, with a membranaceous margin; the pappus is simple, stipated, or stalked. There are 11 species, most of which are plants of no use, and never cultivated but in botanic gardens for variety. That commonly cultivated in the kitchen-garden is the sative, which includes the following varieties: 1. The common or garden lettuce. 2. Cabbage lettuce. 3. Silesia lettuce. 4. Dutch brown lettuce. 5. Aleppo, or sperm lettuce. 6. Imperial lettuce. 7. Green capuchin lettuce. 8. Versailles, or upright white cos lettuce. 9. Black cos. 10. Red cos. 11. Red capuchin lettuce. 12. Roman lettuce. 13. Prince lettuce. 14. Royal lettuce. 15. Egyptian cos lettuce.

The first of these sorts is very common in all gardens, and is commonly sown for cutting very young, to mix with other salad herbs in spring, and the second, or cabbage lettuce, is only this mended by culture. The first crop should be sown in February, in an open situation; the others at three weeks distance; but the later ones under covert, but not under the drippings of trees. The silesia, imperial, royal, black, white, and upright cos lettuces, may be first sown in the latter part of February or the beginning of March, on a warm light soil, and in an open situation: when the plants are come up, they must be thinned to 15 inches distance every way; they will then require no further care then the keeping them clear of weeds; and the black cos, as it grows large, should have its leaves tied together to whiten the inner part. Succeeding crops of these should be sown in April, May, and June; and towards the latter part of August they may be sown for a winter crop, to be preserved under glasses, or in a bed arched over with hoops and covered with mats. The most valuable of all the English lettuces are the white cos, or the Versailles; the Silesia; and the Egyptian cos. The brown Dutch and the green capuchin are very hardy, and may be sown late under walls, where they will stand the winter, and be valuable when no others are to be had. The red capuchin, Roman, and prince lettuce, are very early kinds, and are sown for variety; as are also the Aleppo ones for the beauty of their spotted leaves.

The several sorts of garden lettuces are very wholesome, emollient, cooling salad herbs, easy of digestion, and somewhat loosening the belly. Most writers suppose that they have a narcotic quality; and indeed in many cases contribute to procure rest: this they effect by abating heat, and relaxing the fibres. The seeds are in the number of the four lesser cold seeds.

LACUNAR. See Architecture.

LADDERS, *scaling*, in the military art, are used in scaling when a place is to be taken by surprise. They are made several ways: in England they are made of flat staves, so that they may move about their pins, and shut like a parallel ruler, for conveniently carrying them: the French make them of several pieces, so as to be joined together, and to be made of any necessary length: sometimes they are made of single ropes, knotted at proper distances, with iron hooks at each end, one to fasten them upon the wall above, and the other in the ground; and sometimes they are made with two ropes, and staves between them, to keep the ropes at a proper distance, and to tread upon. When they are used in the action of scaling walls, they ought to be rather too long than too short, and to be given in charge only to the stoutest of the detachment. The soldiers should carry these ladders with the left-arm passed through the second step, taking care to hold them upright close to their sides, and very short below, to prevent any accident in leaping into the ditch.

The first rank of each division, provided with ladders, should set out with the rest at the signal, marching resolutely with their firelocks slung, to jump into the ditch: when they are arrived they should apply their ladders against the parapet, observing to place them towards the salient angles rather than the middle of the curtin, because the enemy have less force there. Care must be taken to place the ladders within a foot of each other, and not to give them too much or too little slope, so that they may not be overturned or broken with the weight of the soldiers mounting upon them.

The ladders being applied, those who have carried them, and those who come after, should mount up, and rush upon the enemy sword in hand: if he who goes first happens to be overturned, the next should take care not to be thrown down by his comrade; but, on the contrary, immediately mount himself, so as not to give the enemy time to load his piece.

As the soldiers who mount first may be easily tumbled over, and their fall may cause the attack to fail, it would perhaps be right to protect their breasts with the fore parts of cuirasses; because if they can penetrate the rest may easily follow.

LADY'S smock. See Cardemine.

Lady's slipper. See Cypripedium.

LAETIA, a genus of the monogynia order, in the polyandria class of plants, and in the natural method ranking with those of which the order is doubtful. The corolla is pentapetalous, or none; the calyx is pentaphyllous; the fruit is unilocular and trigonal; the seeds have a pulpy arillus or coat. There are four species, natives of America. One of them, the apetala, or gum-wood,

Dr. Wright informs us, is very common in the woodlands and copses of Jamaica, where it rises to a considerable height and thickness. Pieces of the trunk or branches, suspended in the heat of the sun, discharge a clear turpentine or balsam, which concretes into a white resin, and which seems to be the same as gum sandarach. Pounce is there made of it, and our author is of opinion that it might be useful in medicine like other gums of the same nature.

LAGERSTROEMIA, a genus of the monogynia order, in the polyandria class of plants. The corolla is hexapetalous, and curled; the calyx sexfid, and campanulated; there are many stamina, and of these the six exterior ones thicker than the rest, and longer than the petals. There are four species, trees of the East Indies.

LAGOECIA, a genus of the monogynia order, in the pentandria class of plants. The involucrum is universal and partial; the petals bifid; the seeds solitary, inferior. There is one species, wild cummin, an annual of the Levant.

LAGUNEA, a genus of the class and order monadelphia polyandria. The calyx is simple, five-cusped; style simple; stigma peltated; capsule five-celled, five-valved. There are three species, shrubs of the East Indies and Surinam.

LAGURUS, a genus of the digynia order, in the triandria class of plants, and in the natural method raking under the fourth order, gramina. The calyx is bivalved with a villous awn, the exterior petal of the corolla terminated by two awns, with a third on its back retorted. There is one species, a grass of the south of Europe.

LAKES, certain colours made by combining the colouring matter of cochineal, or of certain vegetables, with pure alumine, or with oxide of tin, zinc, &c.

LAMA, the sovereign pontiff, or rather god, of the Asiatic Tartars, inhabiting the country of Barantola. The lama is not only adored by the inhabitants of the country, but also by the kings of Tartary, who send him rich presents, and go in pilgrimage to pay him adoration, calling him lama-congiu, *i. e.* God the everlasting father of heaven. He is never to be seen but in a secret place of his palace, amidst a great number of lamps, sitting cross-legged upon a cushion, and adorned all over with gold and precious stones; where, at a distance, they prostrate themselves before him, it not being lawful for any to kiss even his feet. He is called the great lama, or lama of lamas, that is, priest of priests. And to persuade the people that he is immortal, the inferior priests, when he dies, substitute another in his stead, and so continue to cheat from generation to generation. These priests persuade the people that the lama was raised from death many hundred years ago, that he has lived ever since, and will continue to live for ever.

LAMINÆ, in physiology, the thin plates of which many substances consist.

LAMIUM, *dead-nettle*, a genus of the gymnospermia order, in the didynamia class of plants, and in the natural method ranking under the 42d order, verticillatæ. The upper lip of the corolla is entire, arched, the under lip bilobous; the throat with a dent or tooth on each side of the margin. There are 13 species, of which only two, viz. the album, white archangel or dead-nettle, and the purpureum, or red archangel, deserve notice. The flowers of the first, which appear in April and May, have been particularly celebrated in uterine fluors, and other female weaknesses, and also in disorders of the lungs; but they appear to be of very weak virtue. The young leaves of both species are boiled and eaten in some places like greens.

LAMP, a vessel containing oil, with a lighted wick; of which there are an indefinite number made of various constructions for various purposes. We shall particularly notice Argand's lamp, and an improvement made upon it.

Argand's lamp is a very ingenious contrivance, and is the invention of a citizen of Geneva. The principle on which the superiority of the lamp depends, is the admission of a larger quantity of air to the flame than can be done in the common way. This is accomplished by making the wick of a circular form, by which means a current of air rushes through the cylinder on which it is placed, with great force; and, along with that which has access to the outside, excites the flame to such a degree that the smoke is entirely consumed. Thus both the light and heat are prodigiously increased, at the same time that there is a very considerable saving in the expense of oil, the consumption of the inflammable matter being exceedingly augmented by the quantity of air admitted to the flame; so that what in common lamps is dissipated in smoke is here converted into a brilliant flame.

This lamp is now very much in use, and is consequently well known.

We shall now describe an improvement of this neat invention. See Plate LXXV. Lamp, &c.

The upper compartment of the Plate represents an improved construction of Argand's lamp. A. fig. 1, is the reservoir for the oil, which unscrews at B; in order to fill it the oil is poured in at a hole *a*, fig. 4, in the lower end of the reservoir, which is covered, when the lamp is not burning, by a sliding collar, *b*, drawn up by a handle, *d*, which comes through a hole in the screw *e*, by which the reservoir is screwed in the short tube, E, fig. 1: there being no vent-holes in the upper part of the reservoir, A, to admit the air as the oil runs out, a bubble of air must enter the hole *a*, fig. 4, to supply the place of every drop of oil that comes out, when the reservoir, A, is screwed to the tube, E; the collar, *b*, being down, the oil runs out (the air being admitted from without through a small hole, *f*), till E is filled above the level of the hole, *a*, which prevents more air getting in; it remains in this state till by the burning of the lamp the oil is drawn down beneath the hole *a*, when it is filled again as before; by this means the lamp is always well supplied, but never overstocked with oil. From the bottom of the tube, E, fig. 1, the oil is conveyed by a pipe, D, to the lamp, the constitution of which is best explained in fig. 2; EF is the external tube of brass, which is supplied with oil by the pipe D; in the centre of this another tube, GG, is soldered, which is open at both ends: between these tubes is a cylinder of slightly wove cotton, *gg*, called the wick; this is fastened to a small cylinder of brass, *hh* (shown separately in fig. 3), which can be moved down and up as the wick burns. The wick is lowered or raised by turning round the cylinder, HH (shown separately in fig. 5), by means of its rim, II, fastened to the cylinder, HH, by three small rods, *ii*: the cylinder, HH, fig. 5, has a spiral groove, *kk*, cut obliquely round

it: the cylinder, hh, figs. 2 and 3, which goes within the cylinder, HH, has a small stub, l, projecting from it, which works into the groove, kk, fig. 5; the leaf, l, is long enough to project a small distance through the groove, kk, and when in its place takes against a small bead, n, fig. 2, fixed withinside the cylinder, FF, so as to prevent its turning, when HH is turned by its rim, II. By the above arrangement it is evident, that when the cylinder, HH, fig. 5, is turned round, and h is prevented from turning, the sides of the groove, k, will act as an inclined plane against the stub, l, and raise the cylinder h down or up, and the cotton wick, gg, with it. The rim, II, figs. 1, 2, and 5, has an ornamented border, L, round it, which serves to secure the glass chimney, c, from being overthrown. To prevent the cylinder, HH, from being lifted out by accident, it has a rim, o, figs. 2 and 5, at the lower end, cut through in one place to allow it to pass down by the bead, n; when it is below the end of the bead it cannot be raised, unless the notch in the rim, o, corresponds with the bead. When the wick, gg, figs. 1 and 5, is lighted, it rarefies the air in the glass chimney, O, and causes a draught through the tube, GG, to supply the inside of the wick, and also under the edge of the glass chimney to supply the outside: as the wick burns down it can be raised from time to time by turning the rim, I, as before described. The tube, FF, is always nearly full of oil, brought by the pipe, D. When it is required to put in a new wick, the glass chimney, O, is lifted off; the tube, hh, is screwed up to the top; by turning the rim, II, the tube, fig. 3, is then taken out, the old wick pulled off, and a new one is put round the small part, m, of the tube, which is then put in again, and screwed down to the proper depth for lighting the wick.

Rolling-Lamp, a machine, AB (see Pl. LXXVIII. Mis. fig. 145) with two moveable circles, DE, FG, within; whose common centre of motion and gravity is at K, where their axes of motion cross one another. If the lamp, KC, made pretty heavy, and moveable about its axis, HI, and whose centre of gravity is at C, be fitted within the inner circle, the common centre of gravity of the whole machine will fall between K and C; and by reason of the pivots A, B, D, E, H, I, will be always at liberty to descend: hence, though the whole machine be rolled along the ground, or moved in any manner, the flame will always be uppermost, and the oil cannot spill.

It is in this manner they hang the compass at sea; and thus should all the moon-lanterns be made that are carried before coaches, chaises, and the like.

Lamp-black, among colourmen. See Black.

LAMPREY. See Petromyzon.

LAMPYRIS, *glow-worm*, a genus of insects of the order coleoptera: the generic character is, antennæ filiform; wing-sheaths flexile; thorax flat, semiorbicular, concealing and surrounding the head; abdomen with the sides pleated into papillæ; female (in most species) wingless. The lampyris noctiluca, or common glow-worm, is a highly curious and interesting animal. It is seen during the summer months as late as the close of August, if the season is mild, on dry banks, about woods, pastures, and hedgeways, exhibiting, as soon as the dusk of the evening commences, the most vivid and beautiful phosphoric splendour, in form of a round spot of considerable size. The animal itself, which is the female insect, measures about three quarters of an inch in length, and is of a dull earthy brown colour on the upper parts, and beneath, more or less tinged with rose-colour, with the two or three last joints of the body of a pale or whitish sulphur-colour. It is from these parts that the phosphoric light abovementioned proceeds, which is of a yellow colour, with a very slight cast of green: the body, exclusive of the thorax, consists of ten joints or divisions. The larva, pupa, and complete female insect, scarcely differ perceptibly from each other in general appearance, but the phosphoric light is strongest in the complete animal. The glow-worm is a slow-moving insect, and in its manner of walking frequently seems to drag itself on by starts, or slight efforts. The male is smaller than the female, and is provided both with wings and wing-sheaths; and it is but rarely seen.

It is certain, that in some species of this genus the male, as well as the female, is luminous; as in the lampyris Italica, which seems to be a native of England also, though less common there than in the warmer parts of Europe. Aldrovandus describes the winged glow-worm as having its wing-shells of a dusky colour, and at the end of the body two brilliant fiery spots like the flame of sulphur. See Plate LXXVII. Nat. Hist. figs. 238, 239.

In the Philosophical Transactions for the year 1684, we find a paper by a Mr. Waller, describing the English flying glow-worm as of a dark colour, with the tail part very luminous. He maintains that both male and female of this species are winged, and that the female is larger than the male: the light of this insect was very vivid, so as to be plainly perceived even when a candle was in the room. Mr. Waller observed this species at Northaw, in Hertfordshire. From the figure given by this writer it appears to be about half an inch in length, which is much smaller than the common female glow-worm.

In Italy this flying glow-worm is extremely plentiful; and we are informed by Dr. Smith and other travellers, that it is a very common practice for the ladies to stick them by way of ornament in different parts of their head-dress during the evening hours.

The common or wingless glow-worm may be very successfully kept, if properly supplied with moist turf, grass, moss, &c. for a considerable length of time; and as soon as the evening commences, will regularly exhibit its beautiful effulgence, illuminating every object within a small space round it, and sometimes the light is so vivid as to be perceived through the box in which it is kept. This insect deposits its eggs, which are small and yellowish, on the leaves of grass, &c. There are 18 species of the lampyris.

LAND, in the sea language, makes part of several compound terms: thus *land-laid*, or to lay the land, is just to lose sight of it. *Land-locked*, is when land lies round the ship, so that no point of the compass is open to the sea: if she is at anchor in such a place, she is said to ride land-locked, and is therefore concluded to ride safe from the violence of winds and tides. *Land-mark*, any mountain, rock, steeple, tree, &c. that may serve to make the land known at sea. *Land is shut in*, a term used to signify that another point of land hinders the sight of that the ship came from. *Land to*, or the ship

lies land to, that is, she is so far from shore that it can only be just discerned. *Land-turn*, is a wind that in almost all hot countries blows at certain times from the shore in the night. *To set the land*, that is, to see by the compass how it bears.

LANDSCAPE. See PAINTING.

LAND-TAX, an ancient branch of the public revenue, the origin of which may be traced to the fines or commutations for military service, levied during the feudal system under the name of scutages. These are supposed to have been at first mere arbitrary compositions, as the king and the persons liable could agree; but the practice having been much abused, it was declared by Magna Charta, and afterwards repeatedly confirmed by acts of parliament, that no scutage should be imposed without the consent of the great men and commons, in parliament assembled. This tax was sometimes exacted under the name of hydage, or carrucage; but taxes on land came afterwards to be generally denominated subsidies, or assessments. During the Commonwealth, taxes on land were levied by monthly assessments; and commissioners were appointed in each county for rating the individuals. These assessments varied according to the exigencies of the times, from 35,000*l.* to 120,000*l.* a month; the assessments in Scotland were commonly 6000*l.* but sometimes 1000*l.* a month; in Ireland 9000*l.* a month. This mode of raising money was found so productive, that, with some little variations, it has under the denomination of land-tax ever since formed an important branch of the revenue.

The land-tax, till lately, differed from all the other branches of the public revenue (except part of the duties on malt), in being imposed annually, whereas other taxes have been granted either for a term of years, or, more commonly of late years, for ever; but though granted for only one year at a time, it has been regularly continued from year to year since the Revolution, having never been wholly taken off; but it has varied with respect to the rate at which it has been imposed, having been usually reduced during peace, and increased again in time of war, to answer, in part, the increased expenditure. In 1693 it was first raised to four shillings in the pound, upon a valuation given in the preceding year, and according to which it has continued to be raised to the present time, at the following rates:

In 1698 and 1699, at 3*s.*
1700, at 2*s.*
1701, at 3*s.*
1702 to 1712, at 4*s.*
1713 to 1715, at 2*s.*
1716, at 4*s.*
1717 to 1721, at 3*s.*
1722 to 1726, at 2*s.*
1727, at 4*s.*
1728 and 1729, at 3*s.*
1730 and 1731, at 2*s.*
1732 and 1733, at 1*s.*
1734 to 1739, at 2*s.*
1740 to 1749, at 4*s.*
1750 to 1752, at 3*s.*
1753 to 1755, at 2*s.*
1756 to 1766, at 4*s.*
1767 to 1770, at 3*s.*
1771, at 4*s.*
1772 to 1775, at 5*s.*
1776 to 1798, at 4*s.*

The sums to be raised at 4*s.* in the pound were stated, in the annual act, at 1,989,673*l.* 7*s.* 10¾*d.* for England, and 47,954*l.* 1*s.* 2*d.* for Scotland, making together 2,037,627*l.* 9*s.* 0¾*d.*; and upon credit of this assessment 2,000,000*l.* was annually borrowed of the Bank in anticipation of the tax, for which sum exchequer-bills were given them, which were to be discharged out of the produce of the tax as it came in; but the full amount of the assessment was seldom, if ever, collected, so that the nett payments into the exchequer always fell short of the sum borrowed on the credit thereof, exclusive of interest on the bills; and the deficiency was made good out of the supplies for the next year.

In 1798 the current value of the public funds having been unusually depressed for some time past, and apprehensions being entertained that the further increase of the funded debt would be attended with peculiar inconvenience, unless some mode was discovered of counteracting its effects, a project was adopted of offering the land-tax for redemption or sale. With this view an act was passed, making the land-tax a perpetual tax, from 25th March, 1799; and being thus converted into a permanent annuity, it was offered for sale to the proprietors of the lands upon which it was charged; or if they declined it, to any other person who chose to become a purchaser. In the first case it was considered as a redemption of the tax, the estate becoming in future wholly freed from it; in the latter case the purchaser became entitled to receive the land tax regularly from the receiver-general, half-yearly, on the 16th of March and 20th of September in every year. The consideration to be given in either case was not to be in money, but stock, either in the three per cent. consols., or three per cent. reduced, to be transferred to the commissioners for the reduction of the national debt. The quantity of stock to be transferred for redemption of the tax by persons interested in the land on which it was charged, was so much capital as yielded an annuity or dividend exceeding the amount of the tax to be redeemed by one-tenth part thereof; and the stock to be transferred for purchase of the tax by persons not interested in the land, was so much capital as yielded an annuity or dividend exceeding the tax to be purchased by one-fifth part thereof. Thus the amount of three per cent. stock to be transferred for 10*l.* per annum tax was 366*l.* 13*s.* 4*d.* for redemption, or 400*l.* for purchase.

This scheme was adopted with the view of facilitating the raising of money on loan, by absorbing a large quantity of floating stock, and thus raising the current price; while at the same time it would be attended with an increase of revenue. This at least was the avowed object of the measure, which it was estimated would be the means of redeeming or taking out of the market about 80,000,000*l.* of stock; the advantages offered by it were, however, by no means such as to induce a general approval of it, many persons subject to the tax declined redeeming it, and but few were inclined to become purchasers. The period first limited was several times extended, but the plan succeeded very imperfectly, and on the 1st February, 1803, the total amount of 3 per

cent. stock, which had been transferred for the redemption of land tax, was only 21,794,307*l.* 17*s.* 3*d.*

LANERIA, a genus of the hexandria monogynia class and order. The corolla is superior, woolly; the caps. three-celled. There is one species, a herb of the Cape.

LANGAYA, a genus of serpents: the generic character is, abdominal plates; caudal rings; terminal scales.

Langaya nasuta, snouted langaya. The genus langaya, consisting of a single species only, differs from all the rest of the serpent tribe in having the upper part or beginning of the tail marked into complete rings or circular divisions resembling those on the body of the amphisbena, while the extreme or terminal part is covered with small scales, as in the genus anguis.

The langaya nasuta, or long snouted langaya, is in length about two feet eight inches, and its greatest diameter about seven lines: the head is covered with large scales, but the snout, which is extremely long and sharp, projecting to a considerable distance beyond the lower jaw, is covered with very small scales; the teeth, in shape and disposition, resemble those of a viper. The natives of Madagascar are said to hold the langaya in great dread, considering it as a highly poisonous serpent.

LANGUED, in heraldry, expresses such animals whose tongue appearing out of the mouth, is borne of a different colour from that of the body.

LANIUS, the *shrike* or *butcher-bird;* a genus belonging to the order of accipitres, the characters of which are these: the beak is somewhat straight, with a tooth on each side towards the apex, and naked at the base; and the tongue is lacerated.

1. The excubitor, great cinereous shrike, or greater butcher-bird, is in length 10 inches. The plumage on the upper parts is of a pale ash-colour; the under, white; through the eyes there is a black stripe; the scapulars are white; the base of the greater quills is white, the rest black. The method of killing its prey is singular, and its manner of devouring is not less extraordinary: small birds it will seize by the throat, and strangle; and which probably is the reason the Germans also call this bird wurchangel, or the suffocating angel. It feeds on small birds, young nestlings, beetles, and caterpillars. When it has killed the prey, it fixes them on some thorn, and when thus spitted, pulls them to pieces with its bill. When confined in a cage, they will often treat their food in much the same manner, sticking it against the wires before they devour it. This bird inhabits many parts of Europe and North America. The female makes its nest with heath and moss, lining it with wool and gossamer, and lays six eggs, about as big as those of a thrush, of a dull olive-green, spotted at the thickest end with black. In spring and summer it imitates the voices of other birds, by way of decoying them within reach, that it may destroy them; but beyond this the natural note is the same throughout all seasons. In countries where they are plenty, the husbandmen value them, on supposition of their destroying rats, mice, and other vermin. They are supposed to live five or six years; and are often trained up for catching small birds in Russia.

2. The collurio, or lesser butcher-bird, is seven inches and a half in length. This bird is much more common than the former species. Mr. Latham suspects its being a bird of passage, never having seen it in winter. It lays six white eggs, marked with a rufous brown circle towards the large end. The nest is generally in a hedge or low bush, near which, it is said, no small bird chooses to build; for it not only feeds on insects, but also on the young of other birds in the nest, taking hold of them by the neck, and strangling them, beginning to eat them first at the brain and eyes. It is fonder of grasshoppers and beetles than of other insects, which it eats by morsels, and when satisfied, sticks the remainder on a thorn: when kept in a cage, it does the same against the wires of it, like the former species.

3. The infaustus, or rock shrike, is in length seven inches and three quarters. The bill is about an inch long, and blackish; the head and neck are of a dark ash-colour, marked with small rufous spots; the upper part of the back is a dark brown; the lower much paler, inclining to ash, especially towards the tail; the quills and wing-coverts are dusky, with pale margins; the breast, and under parts of the body, are orange, marked with small spots, some white and others brown. This species is met with in many parts of Europe, from Italy on the one hand, to Russia on the other; and is found in some parts of Germany, the Alpine mountains, those of Tyrol, and such-like places. The manners of this bird seem disputed. It has an agreeable note of its own, approaching to that of the hedge sparrow; and will also learn to imitate that of others. It makes the nest among the holes of the rocks, &c. hiding it with great art; and lays three or four eggs, feeding the young with worms and insects, on which it also feeds itself. It may be taken young from the nest, and brought up as the nightingale.

4. The faustus, or white-wreathed shrike, is about the size of a common thrush. Its bill is pale; the upper parts of the body are grey; the under ferruginous; from the eyes to the hind head there passes a whitish line, composed of numerous white feathers, rendering it truly characteristic; the wings are rounded; the quills brownish, with grey edges, which are crossed with numerous slender brown lines; the tail is rounded, brown, and crossed with numerous bars of darker brown; the legs are pale. This elegant species inhabits China, where it is known by the name of whommaj. It may be observed, among others, in Chinese paper-hangings, where the white line seems to encompass the back part of the head like a wreath.

5. The tyrannus, or tyrant shrike, is about the size of a thrush. Its bill is a blackish brown, beset with bristles at the base; the irides are brown; the upper parts of the plumage grey brown: the under white; the breast inclines to ash-colour; the head is blackish on the upper part; the base of the feathers on that part in the male is orange, but seldom visible except it erects the feathers, when there appears a streak of orange down the middle of the crown. It inhabits Virginia. There is a variety which inhabits St. Domingo and Jamaica. These birds are called titiri, pipiri, or quiquiri, from their cry, which resembles those words. All authors agree in the manners of these birds, which are ferocious to a great degree while the hen is sitting; no bird whatever dare approach their nest; they will attack the first which comes near, without reserve, and usually come off conquerors.

Many species of this genus are found in Cayenne, and other hot countries, as the lanius varius. See Plate LXXVII. Nat. Hist. fig. 240.

LANNIERS, or LANNIARDS, in a ship, are small ropes reeved into the dead-man's eyes of all shrowds, either to slacken them or to set them tawt; the stays of all masts are also set tawt by lanniers.

LANTANA, or INDIAN SAGE, a genus of the angiospermia order, in the didynamia class of plants, and in the natural method ranking under the 40th order, personatæ. The calyx is indistinctly quadridentated; the stigma broken, and turned back like a hoof; the fruit is a plum with a bilocular kernel. There are 19 species, consisting of shrubby exotics from Africa and America for the greenhouse or stove, growing to the height of a yard or two, and adorned with oblong, oval, and roundish simple leaves, with monopetalous, tubular, four-parted flowers of different colours. They may be propagated either by seeds or cuttings. 1. The camara or wild sage, is remarkable for the beauty of its flowers, which are yellow, tinged with red. 2. The involucrata, or sea-side sage, has small ash-coloured leaves and a most agreeable smell. They are both natives of the West Indies, the former growing wild among the bushes, and the latter being found near the sea. Their leaves, particularly those of the sea-side sage, are used by the black people in teas for colds and complaints of the stomach. 3. The aculeata is a beautiful stove plant, remarkable for its flowers changing from yellow to red. See Plate LXXVII. Nat. Hist. fig. 243.

LANTERN, MAGIC, an optic machine, whereby little painted images are represented so much magnified, as to be accounted the effect of magic by the ignorant. See OPTICS.

LANTERN. See ARCHITECTURE.

LAPIDARY. There are various machines employed in the cutting of precious stones, according to the quality: the diamond, which is extremely hard, is cut on a wheel of soft steel, turned by a mill, with diamond-dust, tempered with olive-oil, which also serves to polish it.

The Oriental ruby, sapphire, and topaz, are cut on a copper wheel with diamond-dust, tempered with olive-oil, and are polished on another copper wheel with tripoli and water. The hyacinth, emerald, amethyst, garnets, agates, and other stones, not of an equal degree of hardness with the other, are cut on a leaden wheel with smalt and water, and polished on a tin wheel with tripoli. The turquois of the old and new rock, girasol, and opal, are cut and polished on a wooden wheel with tripoli also.

LAPIS, in general, is used to denote a stone of any kind. See MINERALOGY.

LAPIS *calcedonius*, a genus of stones consisting of silica, a small quantity of alumina, with about one-tenth of lime, and a slight trace of oxide of iron: hard, lightish, shining within, breaking into fragments with sharp edges; compact, not mouldering in the air; of a more or less perfectly conchoidal texture; never opake, tough, admitting of a high polish, and generally of a common form; not melting before the blowpipe. See Pl. LXXVII. Nat. Hist. fig. 241.

LAPLYSIA, or SEA-HARE, a genus of marine insects belonging to the order of vermes mollusca. See Plate LXXVII. The body is covered with membranes reflected. It has a shield-like membrane on the back, a lateral pore on the right side, the anus on the extremity of the back, with four feelers resembling ears. The figure represents the depilans minor, which grows to two inches and a half in length, and to more than an inch in diameter; its body approaches to an oval figure, and is soft, punctated, of a kind of gelatinous substance, and of a pale lead-colour; from the larger extremity there arise four oblong and thick protuberances: these are the tentacula; two of them stand nearly erect, two are thrown backward. It is not uncommon about the shores, especially off Anglesea. It causes, by its poisonous juice, the hair to fall off the hands of those that touch it; and is so extremely fetid as to create sickness at the stomach. The major, or greater sea-hare, grows to the length of eight inches.

LAPPAGO, a genus of the triandria digynia class and order. There is one species, a grass.

LAPSANA, *nipplewort*, a genus of the polygamia æqualis order, in the syngenesia class of plants, and in the natural method ranking under the 49th order, compositæ. The receptacle is naked; the calyx caliculated, with all the inferior scales canaliculated or finely channelled. There are five species, which grow commonly as weeds by the sides of ditches. The young leaves of the common kind, called dock-cresses, have the taste of radishes, and are eaten raw at Constantinople as a sallad. In some parts of England the common people boil them as greens, but they have a bitter and disagreeable taste.

LAPSE, the omission of a patron to present to a church, within six months after voidable; by which neglect title is given to the ordinary to collate to such church: and in such case, the patronage devolves from the patron to the bishop, from the bishop to the archbishop, and from the archbishop to the king. A donative does not go in lapse; but the ordinary may compel the patron by ecclesiastical censures to fill up the vacancy. But if the donative has been augmented by the governors of queen Anne's bounty, it will lapse in like manner as presentative livings.

LAPSED LEGACY, is where the legatee dies before the testator; or where a legacy is given upon a future contingency, and the legatee dies before the contingency happens. As if a legacy is given to a person when he attains the age of 21 years, and the legatee dies before that age; in this case the legacy is a lost or lapsed legacy, and shall sink into the residuum of the personal estate. 2 Black. 613.

LARBOARD, among seamen, the left hand side of the ship, when you stand with your face towards the head.

LARCENY, is the felonious and fraudulent taking away of the personal goods of another: which goods, if they are above the value of 12*d*. it is called grand larceny; if of that value or under, it is petit larceny: which two species are distinguished in their punishment, but not otherwise. 4 Black. 229.

The mind only makes the taking of another's goods to be felony, or a bare trespass only; but as the variety of circumstances is so great, and the complications thereof so mingled, it is impossible to prescribe all the circumstances evincing a felonious intent, or the contrary: it must therefore be left to the due and attentive consideration of the judge and jury, wherein the best rule is, in

doubtful matters, rather to incline to acquittal, than conviction. But in general it may be observed, that the ordinary discovery of a felonious intent, is, if the party do it secretly, or being charged with the goods deny it. 1 H. H. 509.

As all felony includes trespass, every indictment must have the words feloniously took, as well as carried away; whence it follows, that if the party being guilty of no trespass in taking the goods, he cannot be guilty of felony in carrying them away. 1 Haw. 89.

With respect to what shall be considered a sufficient carrying away, to constitute the offence of larceny; it seems that any the least removing of the thing taken, from the place where it was before, is sufficient for this purpose, though it be not quite carried off. 1 Haw. 93.

As grand larceny is a felonious and fraudulent taking of the mere personal goods of another above the value of 12*d.* so it is petit larceny, where the thing stolen is but of the value of 12*d.* or under. In the several other particulars above-mentioned, petit larceny agrees with grand larceny. 1 Haw. 95.

In petit larceny there can be no accessaries either before or after. 1 H. H. 530.

Larceny from the person. If larceny from the person be done privily without his knowledge, by picking of pockets or otherwise, it is excluded from the benefit of clergy by 8 Eliz. c. 4. provided the thing stolen be above the value of 12*d.* 2 H. H. 336.

But if done openly and avowedly before his face, it is within the benefit of clergy. 1 Haw. 97.

Larceny from the house. Every person who shall be convicted of the feloniously taking away in the day-time, any money or goods of the value of 5*s.* in any dwelling-house, or out-house thereunto belonging, and used to and with the same, though no person be therein, shall be guilty of felony, without benefit of clergy. 39 Eliz. c. 15.

Receiving stolen goods. Any person who shall buy or receive any stolen goods, knowing them to be stolen; or shall receive, harbour, or conceal any felons or thieves, knowing them to be so; shall be deemed accessary to the felony: and being convicted on the testimony of one witness, shall suffer death as a felon convict; but he shall be entitled to his clergy. 5 Anne c. 31.

Any person convicted of receiving or buying stolen goods, knowing them to be stolen, may be transported for fourteen years. 4 Geo. I. c. 11.

Where the principal felon is found guilty to the value of 10*d.* that is, of petit larceny only, the receiver, knowing the goods to have been stolen, cannot be transported for fourteen years, and ought not to be put upon his trial; for the acts which make receivers of stolen goods knowingly, accessaries to the felony, must be understood to make them accessaries in such cases only, where by law an accessary may be; and there can be no accessary to petit larceny. Fost. 74.

Every person who shall apprehend any one guilty of breaking open houses in a felonious manner, or of privately and feloniously stealing goods, wares, or merchandizes, of the value of 5*s.* in any shop, warehouse, coach-house, or stable, though it is not broken open, and though no person is therein to be put in fear, and shall prosecute him to conviction, shall have a certificate without fee, under the hand of the judge, certifying such conviction, and within what parish or place the felony was committed, and also that such felon was discovered and taken, or discovered or taken, by the person so discovering or apprehending; and if any dispute arise between several persons so discovering or apprehending, the judge shall appoint the certificate into so many shares, to be divided among the persons concerned, as to him shall seem just and reasonable. Leache's Cro. Law, 307. See Burglary.

LARK. See Alauda.

LARKSPUR. See Delphinium.

LARVA, in natural history, a name given by Linnæus to insects in that state, called by other writers *erucæ*, or caterpillar.

LARUS, the *gull*, a genus in the order of anseres, the characters of which are: the bill is straight, cultrated, a little crooked at the point, and without teeth; the inferior mandible is gibbous below the apex: the nostrils are linear, a little broader before, and situated in the middle of the beak. The different species are principally distinguished by their colour. The most remarkable are,

1. The marinus, or black-backed gull, in length 29 inches, in breadth five feet nine. The bill is very strong and thick, and almost four inches long; the colour a pale yellow; the head, neck, whole under-side, tail, and lower part of the back, are white; the upper part of the back and wings are black; the quill-feathers tipt with white; the legs of a pale flesh-colour. It inhabits several parts of England, and breeds on the highest cliffs. The egg is blunt at each end, of a dusky olive-colour, quite black at the greater end, and the rest of it thinly marked with dusky spots. It is also common on most of the northern coasts of Europe. It frequents Greenland, but chiefly inhabits the distant rocks. It lays three eggs in May, placing them on the heaps of dung which the birds leave there from time to time. It is said to attack other birds, and to be particularly an enemy to the eider duck. It very greedily devours carrion, though its most general food is fish. It is common also in America, as low as South Carolina, where it is called the old-wife.

2. The cataractes, or Skua gull, is in length two feet; the extent four feet and a half; the weight three pounds; the feathers on the head, neck, back, scapulars, and coverts of the wings, are of a deep brown, marked with rust-colour (brightest in the male). The breast, belly, and vent are ferruginous, tinged with ash-colour. This bird inhabits Norway, the Ferroe isles, Shetland, and the noted rock Foula a little west of them. It is also a native of the South Sea. It is the most formidable of the gulls; its prey being not only fish, but what is wonderful in a web-footed bird, all the lesser sort of water-fowl, such as teal, &c. Mr. Schroter, a surgeon in the Ferroe isles, relates that it likewise preys on ducks, poultry, and even young lambs. The natives of the Orkneys are often very rudely treated by them while they are attending their sheep on the hills, and are obliged to guard their heads by holding up their sticks, on which the birds often kill themselves. In Foula it is a privileged bird, because it defends the flocks from the eagle, which it beats and pursues with great fury; so that even that rapacious bird seldom ventures near its quarters.

3. The parasiticus, or dung-hunter, is in length 21

inches: the upper parts of the body, wings, and tail, are black; the base of the quills white on the inner webs; and the two middle feathers of the tail are near four inches longer than the rest. This is a northern species, and very common in the Hebrides, where it breeds on heath. It comes in May, and retires in August; and if disturbed flies about like the lapwing, but soon alights. It is also found in the Orkneys; and on the coasts of Yorkshire, where it is called the feaser. This bird does not often swim, and flies generally in a slow manner, except in pursuit of other birds, which it often attacks, in order to make them disgorge the fish or other food which this common plunderer greedily catches up.

4. The canus, or common gull, is in length 16 or 17 inches; in breadth 36; weight one pound. The bill is yellow; the head, neck, under parts of the body and tail are white; the back and wings pale-grey. It is a tame species, and may be seen by hundreds on the shores of the Thames and other rivers, in the winter and spring, at low tides, picking up the various worms and small fish left by the tides; and will often follow the plough in the fields contiguous, for the sake of worms and insects which are turned up; particularly the cockchafer or dorbeetle in its larva state, which it joins with the rooks in devouring most greedily.

5. The tridactylus, or tarrock, is in length 14 inches, breadth 36; weight seven ounces. The head, neck, and under parts, are white; near each ear, and under the throat, there is a black spot; and at the hind part of the neck a crescent of black; the back and scapulars are bluish-grey; the wing-coverts dusky edged with grey, some of the larger wholly grey. This species breeds in Scotland, and inhabits other parts of northern Europe, quite to Iceland and Spitzbergen. It is observed frequently to attend the whales and seals, for the sake of the fish which the last drive before them into the shallows, when these birds dart into the water suddenly, and make them their prey.

6. The ridibundus, peewit, or black-head gull, is in length 15 inches, breadth three feet; weight ten ounces; the back and wings are of an ash-colour; the neck, all the under parts, and tail, are white; the first ten quills are white, margined, and more or less tipped with black; the others of an ash-colour. This species breeds on the shores of some of our rivers; but full as often in the inland fens of Lincolnshire, Cambridgeshire, and other parts of England. They make their nest on the ground, with rushes, dead grass, &c. and lay three eggs of a greenish brown, marked with red-brown blotches. After the breeding season, they again disperse to the sea-coasts. The young birds in the neighbourhood of the Thames are thought good eating, and are called the red legs. They were formerly more esteemed, and numbers were annually taken and fattened for the table. Whitelock, in his annals, mentions a piece of ground near Portsmouth, which produced to the owner 40*l.* a year by the sale of peewits, or this species of gull. These are the seagulls that in old times were admitted to the noblemen's tables. The note of these gulls is like a hoarse laugh.

7. The atricilla, or laughing gull, is in length 18 inches, breadth three feet. It is found in Russia on the river Don, particularly about Tschercask. The note resembles a coarse laugh, whence the name of the bird. It is met with also in different parts of the continent of America, and is very numerous in the Bahama islands.

There are 14 or 15 other species of this genus. See Plate LXXVII. Nat. Hist. fig. 242.

LARYNX. See Anatomy.

LASH, or Lace, in the sea language, signifies to bind and make fast.

LASERPITIUM, *lazar-wort*, a genus of the digynia order, in the pentandria class of plants, and in the natural method ranking under the 45th order, umbellatæ. The fruit is oblong, with eight membranaceous angles; the petals inflexed, emarginated, and patent. There are 15 species, none of which are at all remarkable for their beauty, so are only preserved in botanic gardens for the sake of variety.

LASIOSTOMA, a genus of the class and order tetrandria monogynia: the calyx is very short, five-petalled; corolla funnel-form, four-cleft; caps. orbiculate, one-celled, two-seeded. There is one species, a shrub of Guiana.

LASKETS, small lines, like loops, sewed to the bonnets and drablers of a ship, to lash or lace the bonnets to the courses, or the drablers to the bonnets.

LASKING, at sea, is much the same with going large, or veering; that is, going with a quarterly wind.

LAST, in general, signifies the burden or load of a ship. It signifies also a certain measure of fish, corn, wool, leather, &c. A last of codfish, white herrings, meal, and ashes for soap, is 12 barrels; of corn or rapeseed 10 quarters; of gunpowder 24 barrels; of red-herrings 20 cades; of hides 12 dozen; of leather 20 dickers; of pitch and tar 14 barrels; of wool 12 sacks; of stockfish 1000; of flax or feathers 1700 pounds.

LATH, in building, a long, thin, and narrow slip of wood, nailed to the rafters of a roof or ceiling, in order to sustain the covering. These are distinguished into three kinds, according to the different kinds of wood of which they are made, viz. heart of oak, sap-laths, and deal-laths; of which the last two are used for ceilings and partitions, and the first for tiling only. Laths are also distinguished according to their length, into five-feet, four-feet, and three-feet laths, though the statute allows but of two lengths, those of five and those of three feet, each of which ought to be an inch and a half in breadth, and half an inch in thickness, but they are commonly less.

LATHE, a very useful engine for turning of wood, ivory, metals, and other materials. The invention of the lathe is very ancient; Diodorus Siculus says, the first who used it was a grandson of Dædalus, named Talus. Pliny ascribes it to Theodore of Samos, and mentions one Thericles, who rendered himself very famous by his dexterity in managing the lathe. With this instrument the ancients turned all kinds of vases, many whereof they enriched with figures and ornaments in basso relievo. Thus Virgil: "Lenta quibus torno facili superaddita vitis." The Greek and Latin authors make frequent mention of the lathe; and Cicero calls the workmen who uses it vascularii. It was a proverb among the ancients, to say a thing was formed in the lathe, to express its delicacy and justness.

The lathe is composed of two wooden cheeks or sides, parallel to the horizon, having a groove or opening between; perpendicular to these are two other pieces called

puppets, made to slide between the cheeks, and to be fixed down at any point at pleasure. These have two points, between which the piece to be turned is sustained; the piece is turned round, backwards and forwards, by means of a string put round it, and fastened above to the end of a pliable pole, and underneath to a treadle or board moved with the foot. There is also a rest which bears up the tool, and keeps it steady.

The most simple kind of lathe is too well known to require a more ample description. We shall therefore give a figure of an improved lathe manufactured by Mr. Maudslay of Margaret-street. A (Pl. LXXVIII. Misc. fig. 138.) is the great wheel, with four grooves on the rim: it is worked by a crank B and treadle C, in the common way; the catgut which goes round this wheel passes also round a smaller wheel D, called the mandrel, which has four grooves on its circumference of different diameters for giving it different velocities, corresponding with the four grooves on the great wheel A. In order to make the same band suit when applied to all the different grooves on the mandrel D, the wheel A can be elevated or depressed by a screw *a*, and another at the other end of the axle; and the connecting rod C can be lengthened or shortened by screwing the hooks at each end of it further out of, or into it. The end M, fig. 139. of the spindle of the mandrel D, is pointed, and works in a hole in the end of a screw, put through the standard E, fig. 138.; the other end of the bearing F, fig. 139. is conical, and works in a conical socket in the standard, so that by tightening up the screw in E, the conical end F may at any time be made to fit its socket: the puppet G has a cylindric hole through its top to receive the polished pointed rod *d*, which is moved by the screw *e*, and fixed by the screw *f*; the whole puppet is fixed on the triangular prismatic bar H, by a clamp fig. 143, the two ends of which, *a*, *b*, are put through holes *b*, in the bottom of the puppet under the bar, and the whole is fixed by the screw *c* pressing against it; by this means the puppet can be taken off the bar without first taking off the standard I, as in the common lathes; and the triangular bar is found to be far preferable to the double rectangular one in common use. The rest J is a similar contrivance; it is in 3 pieces; see figs. 140. 141, 142. Fig. 141 is a piece, the opening (*a*. *b*, *c*) in which is laid upon the bar H, fig. 138.; the four legs *d d d d* of fig. 142. are then put up under the bar (into the recesses in fig. 141. which are made to receive them), so that the notches in *d d d d* may be level with the top of fig. 141.: the two beads *e f* in fig. 140. are then slid into the notches in the top of *d d d d*, to keep the whole together; the groove *i* is to receive a corresponding piece on *e f*, fig. 140., to steady it; the whole of fig. 140. has a metallic cover, to keep the chips out of the grooves. It is plain, that by tightening the screw *h* in the bottom of figs. 138. and 142., the whole will be fixed and prevented from sliding along the bar H, and fig. 140. from sliding in a direction perpendicular to the bar; the piece *l*, on which the tool is laid, can be raised or lowered at pleasure, and fixed by the screw *m*. On the end *n* of the spindle P, figs. 138. and 139., is screwed occasionally an universal chuck for holding any kind of work which is to be turned (fig. 144.). A is the female screw to receive the screw *n*, fig. 138.; Near the bottom of the screw A is another BB, which is prevented from moving endways by a collar in the middle of it fixed to the screw A.: one end of the screw BB is cut right-handed, and the other left-handed, so that by turning the screw one way, the two nuts EF will recede from each other, or by turning it the contrary way, they will advance towards each other; the two nuts EF pass through an opening in the plate C, and project beyond the same, carrying jaws like those of a vice, by which the subject to be turned is held.

The large lathes which Mr. Maudslay uses in his manufactory, instead of being worked by the foot, as represented in fig. 138., are worked by hand; the wheel and fly-wheel which the men turn work by a strap on another wheel, fixed to the ceiling directly over it; on the axis of this wheel is a larger one, which turns another small wheel or pulley, fixed to the ceiling, directly over the mandrel of the lathe; and this last has on its axis a larger one which works the mandrel D, by a band of catgut. These latter wheels are fixed in a frame of cast iron, moveable on a joint; and this frame has always a strong tendency to rise up, in consequence of the action of a heavy weight; the rope from which, after passing over a pulley, is fastened to the frame. This weight not only operates to keep the mandrill-band tight, when applied to any of the grooves therein, but always makes the strap between the two wheels on the ceiling fit. As it is necessary that the workman should be able to stop his lathe, without the men stopping who are turning the great wheel, there are two pulleys, or rollers, (on the axis of the wheel over the lathe) for the strap coming from the other wheel, on the ceiling; one of these pulleys, called the dead pulley, is fixed to the axis, and turns with it; and the other which slips round it, is called the live pulley: these pulleys are put close to each other, so that by slipping the strap upon the live pulley, it will not turn the axis; but if it is slipped on the other, it will turn with it: this is effected by an horizontal bar, with two upright pins in it, between which the strap passes. This bar is moved in such a direction as will throw the strap upon the live pulley, by means of a strong bell-spring; and in a contrary direction it is moved by a cord fastened to it, which passes over a pulley, and hangs down within reach of the workman's hand: to this cord is fastened a weight, heavy enough to counteract the bell-spring, and bring the strap up to the dead pulley, to turn the lathe; but when the weight is laid upon a little shelf, prepared for the purpose, the spring will act and stop it.

The following is a description of Mr. Smart's newly invented lathe for turning cylinders of wood for the purpose of tent-poles, pickets, handles for tools, &c. &c. the operations of which are so readily performed, that from octagonal bars of yellow deal, $5\frac{1}{2}$ feet long (previously prepared by means of a circular saw) one man, besides two labourers to turn the wheel, will turn out 600 perfectly cylindrical poles, in the space of 12 hours. AA, fig. 6., (Plate Smart's lathe) represents the standards for supporting the great wheel, that gives motion to the lathe; these are supported by pieces of board BB spiked to the ceiling or joists above, and by others CC fixed to the floor of the workshop. The great wheel DD is grooved round the edge for receiving the endless screw B and E, and is put in motion by the winch-handle F F. G and

H are the standards of the lathe, firmly fixed to the floor, and carrying the side-pieces or bed I I; the standard G is tall enough to act as a fixed puppet, and has a screw *a* working through it, for supporting the end of the mandrel or spindle of this lathe, as in the common lathe. K, L, and M, are three other puppets that can be fixed in any place desired, by wedges beneath the bed as usual. To the puppet K is screwed a thick iron plate *b*, which has a conical socket, nicely turned and polished, for receiving the mandrel: this puppet is farther steadied by a brace N, screwed to it, and to the floor of the shop. To the puppet K and L two bars *oo* are fixed by screws, and the same are further supported and steadied by three short puppets P P P. The mandrel, and its pulley Q, are nearly of the common construction, except that the end *c* has a steel point in its centre, and two shorter points for preventing the octagonal piece of wood intended to be turned from slipping or turning without the mandrel. The puppet L has a square-pointed bar *d* fitted to it; and the puppet M has a screw, worked by its handle *e*, which by means of a collar advances or draws back the bar *d*. R is a piece of wood, fixed to the bed and to the floor, for the purpose of carrying a pulley *f*, whose use is to prevent the wheel-band EE from wearing by friction at the place where it crosses. Figs. 7. and 8. represent the gouge and plane, successively used instead of the common turner's chisel, &c.: the pieces of board *aa* are screwed to the block *b*, just at the proper distance of the outsides of the bars *oo*, fig. 1., so that when the tools, figs. 7. and 8. are placed on them, they can be slid along steadily, between the puppets K and L.; the holes *cc* being so adapted as to suit the mandrel and bar *c* and *d* as centres, and their diameters are sufficient to let the octagonal bar intended to be turned to pass through them, without touching; *d*, fig. 7., is a piece of tempered steel, formed as a gouge, and screwed fast to the side of the block, in the proper position for roughing off the angles of the octagonal bar, as it advances, and turns through the hole *c*. *c* fig. 7., is a flat piece of steel, like a plane-iron (shown separately at *f*), which is so fixed by a screw, that it may smooth or complete the cylindrical surface of a pole, already gouged as above, which is advanced, and turned through it. The operation is thus performed: The two tools fig. 7 and 8, are placed on the bar *oo*, fig. 6, and shoved close up to the puppet I; the square bar being long enough for its point *d*, then to project through the centres of the holes *cc*, figs. 7 and 8. The workman then takes an octagonal pole, enters the centre pin of the mandrel *c* into the centre of its end, and the point *d* into the centre of the other end, turning the handle *e* sufficiently to allow the pole to be steadily turned: the wheel D is then set in motion; the workman pushes the gouge-tool, fig. 8., forwards, towards the puppet K, which, as it advances quickly, strikes off the angles of the pole in a rough or screw-like form. When the gouge-tool, fig. 8, has advanced to the end of the pole, the finishing-tool, fig. 7., is in like manner shoved forwards by the workman; and as it advances, the pole is turned into a complete and smooth cylinder. The projection of the mandrel *bc*, fig. 6, is sufficient to admit the gouge and plane tools, to advance so as to clear the end of the pole; and by turning back the handle *c*, the same can be taken out of the lathe as soon as it is stopped. The velocity of the mandrel Q is so as to make upwards of 1200 turns per minute.

LATHRÆA, a genus of the angiospermia order, in the didynamia class of plants, and in the natural method ranking under the 40th order, personatæ. The calyx is quadrifid; there is a depressed glandule at the base of the suture of the germen. The capsule is unilocular. There are four species.

LATHS, *cleaving of.* The lath-cleavers having cut their timbers into lengths, cleave each piece with wedges into 8, 12, or 16, according to the size of their timber; these pieces are called bolts: this is done by the felt grain, which is that grain which is seen to run round in rings at the end of a piece of a tree. Thus they are cut out for the breadth of the laths, and this work is called felting. Afterwards they cleave the laths into their proper thickness with their chit, by the quarter-grain, which is that which runs in straight lines towards the pith.

LATHYRUS, *chickling vetepo*, a genus of the decandria order, in the diadelphia class of plants, and in the natural method ranking under the 32d order, papilionacea. The stylus is plain, villous above, towards the end broader; the upper two segments of the calyx are shorter than the rest.

The species are 23, among which are: 1. The latifolius, or everlasting pea. 2. The odorata, or sweet-scented pea. 3. The tangitenus, or Tangier-pea, also an annual, and well known.

LATITAT, a writ whereby all men in personal actions are called originally to the king's bench. F. N. B. 78.

A latitat may be considered either as the commencement of the action, or only as a process to bring the defendant into court, at the election of the plaintiff. Bul. N. P. 151.

If it is stated as the commencement of the action to avoid a tender, the defendant may deny that the plaintiff had any cause of action at the time of suing it out. 1 Wils. 141.

Or if it is replied to a plea of the statute of limitations, the defendant, in order to maintain his plea, may aver the real time of suing it out, in opposition to the test. 2 Burr. 950. See Impey's B. R. and C. B. Practice.

LATITUDE. See GEOGRAPHY.

LATITUDE. See ASTRONOMY.

LATTEN denotes iron plates tinned over, of which tea-canisters are made.

LATTEN-BRASS, plates of milled brass, reduced to different thickness, according to the uses it is intended for.

LATUS RECTUM, in conic sections, the same with parameter. See CONIC SECTIONS.

LATUS TRANSVERSUM, in the hyperbola, that part of the transverse diameter, intercepted between the vertices of the two opposite sections.

LAVANDULA, *lavender:* a genus of the angiospermia order, in the didynamia class of plants, and in the natural method ranking under the 42d order, verticillatæ. The calyx is ovate, and little dentated, supported by a bractea or floral leaf; the corolla is resupinated; the stamina within the tube.

The species are seven in number, among which are: 1. The spica, or spike lavender, has a short shrubby stalk. The varieties of this are: common narrow-leaved laven-

der, with blue flowers, and with white flowers; broad-leaved lavender; dwarf lavender: all of them flowering in July. This species is the common lavender; but the narrow-leaved variety, with blue flowers, is the sort commonly cultivated for its flowers for medicine. 2. The stœchas, or French lavender, has a shrubby very branchy stalk, rising two or three feet high; very narrow, spear-shaped, pointed, hoary leaves, opposite; and all the branches terminated by short bushy spikes of purple flowers in June and July, succeeded by seeds in August. There is a variety with white flowers. 3. The dentata, or dentate-leaved stœchas, has a woody stalk, branching on every side three or four feet high; leaves deeply indented in a pinnated manner; and the branches terminated by scaly four-cornered spikes of flowers, appearing most part of summer.

The first two species are proper for the kitchen-garden, and for medicinal and other family uses, and to plant in the pleasure-ground to adorn the front of small shrubbery compartments, where they will increase the variety very agreeably; and are finely scented aromatics, both when growing, and their flowers when gathered; especially those of the first species, which are in great esteem for putting among clothes, and for distilling, and other economical uses. The flowers of the first sort are gathered for use in July.

LAVATERA, a genus of the polyandria order, in the polydelphia class of plants, and in the natural method ranking under the 37th order, columniferæ. The exterior calyx is double and trifid; the arilli or seed-coats are very many and monospermous. There are 9 species, most of them herbaceous flowery annuals, or shrubby perennials, growing erect from two or three to eight or ten feet high. They are easily propagated by seed in the open ground in the spring, and thrive best when sown where they are designed to remain.

LAUDANUM. See Pharmacy.

LAUGERIA, a genus of the monogynia order, in the pentandria class of plants, and in the natural method ranking among those of which the order is doubtful. The corolla is quinquefid; the fruit is a plum with a quinquelocular kernel. There are two species, shrubs of the West Indies.

LAUNCH, in the sea-language, signifies to put out: as, launch the ship, that is, put her out of the dock; launch aft, or forward, speaking of things that are stowed in the hold, is, put them more forward; launch, ho! is a term used when a yard is hoisted high enough, and signifies hoist no more.

LAUNDER, among miners, a place where they wash the powdered ore.

LAUREATION, in the universities of Scotland, signifies the act of taking the degree of master of arts, which the students are permitted to do after four years study.

LAURUS, *the bay-tree*, a genus of the monogynia order, in the enneandria class of plants, and in the natural method ranking under the 12th order, holoraceæ. There is no calyx; the corolla is calycine, or serving in place of the calyx, and sexpartite: the nectarium with three glandules, each terminated by two bristles surrounding the germen. The interior filaments furnished with glandules at the base; the fruit a monospermous plum. There are 32 species, of which the most noted are: 1. The nobilis, or evergreen bay-tree, a native of Italy, and has an upright trunk branching on every side from the bottom upward, with spear-shaped, nervous, stiff, evergreen leaves, three inches long, and two broad; and small, yellowish, quadrifid, diœcious flowers, succeeded by red berries in autumn and winter. Of this species there are varieties, with broad, narrow, striped, or waved leaves. 2. The æstivalis, or deciduous bay, grows naturally in North America. It rises with an upright stem, covered with a purplish bark, having oblong, oval, acuminated, veined, deciduous leaves, two or three inches long, and half as broad, growing opposite, with small white flowers succeeded by red berries. 3. The benzoin, or benjamin tree, is also a native of North America; grows 15 or 20 feet high, divided into a very branchy head, with oval, acute, deciduous leaves, three or four inches long, and half as broad; and small yellowish flowers, not succeeded by berries in England. This, it is to be remarked, is not the tree which bears the gum benzoin, that being a species of hyrax. 4. The sassafras is a native of the same country. It has a shrub-like straight stem, with both oval and three-lobed, shining, deciduous leaves, of different sizes, from three to 6 inches long, and nearly as broad, with small yellowish flowers succeeded by blackish berries, but not in England. 5. The indica, or Indian bay-tree, rises with an upright straight trunk, branching regularly 20 or 30 feet high, adorned with very large, spear-shaped, plane, nervous, evergreen leaves on reddish footstalks; and bunches of small whitish-green flowers, succeeded by large oval black berries, which do not ripen in England. 6. The barbonia, or Carolina red bay-tree, rises with an upright straight stem, branching 15 or 20 feet high; with large, spear-shaped, evergreen leaves, transversely veined; and long bunches of flowers on red footstalks, succeeded by large blue berries sitting in red cups. 7. The camphora, or camphor-tree, grows naturally in the woods of the western parts of Japan, and in the adjacent islands. See Pl. LXXVII. Nat. Hist. fig. 244. The root smells stronger of camphor than any of the other parts, and yields it in greater plenty. The bark of the stalk is outwardly somewhat rough; but in the inner surface smooth and mucous, and therefore easily separated from the wood, which is dry, and of a white colour. The flowers are produced on the tops of footstalks, which proceed from the armpits of the leaves; but not till the tree has attained considerable age and size. The flower-stalks are slender, branched at the top, and divided into very short pedicles, each supporting a single flower. These flowers are white, and consist of six petals, which are succeeded by a purple and shining berry of the size of a pea, and in figure somewhat top-shaped. It is composed of a soft pulpy substance, that is purple, and has the taste of cloves and camphor; and of a nucleus or kernel of the size of a pepper, which is covered with a black, shining, oily corticle, of an insipid taste. 8. The cinnamomum, or cinnamon-tree, is a native of Ceylon. It has a large root, and divides into several branches, covered with a bark, which on the outer side is of a greyish brown, and on the inside has a reddish cast. The wood of the root is hard, white, and has no smell. The body of the tree, which grows to the height of 20 or 30 feet, is covered, as well as its numerous branches, with a bark which at first

is green and afterwards red. The leaf is longer and narrower than the common bay-tree; and it is three-nerved, the nerves vanishing towards the top. When first unfolded, it is of a flame-colour; but after it has been for some time exposed to the air, and grows dry, it changes to a deep green on the upper surface, and to a lighter on the lower. The flowers are small and white, and grow in large bunches at the extremity of the branches: they have an agreeable smell, something like that of the lily of the valley. The fruit is shaped like an acorn, but is not so large. 9. The cassia, or base cinnamon, has lanceolated leaves, triple-nerved. 10. The persea, avocado-pear tree, or alligator pear, rises to a considerable height, with a straight trunk, of which the bark and wood are of a greyish colour. The leaves are long, oval, pointed, of a substance like leather, and of a beautiful green colour. The flowers are produced in large knots or clusters, at the extremities of the branches, and consist each of six petals disposed in the form of a star, and of a dirty-white or yellow colour, with an agreeable odour, which diffuses itself to a considerable distance. It is a native of the West Indies. The persea begins to bear two years and a half, or at most three years, after being planted; and like most of the trees in warm climates, bears twice a year.

LAVENIA, a genus of the class and order syngenesia polygamia æqualis. The calyx is nearly regular; style bifid; down three-awned; recept. naked. There are two species, herbs of the East and West Indies.

LAW. Laws of England are divided into lex non scripta, or the common law; and lex scripta, or statute law.

The lex non scripta is not so called from its being conveyed down from former ages by word of mouth, but because the original authority of these laws is not set down in writing, and they receive their force by long usage, and by their universal reception throughout the kingdom; and it is curious to observe, that these rude maxims of our ancestors, of which no person knows clearly the origin, exceed in clearness, brevity, and authority, all that the united wisdom of the most enlightened men have produced in later ages.

The common law is divided into:

1st. General custom, which is the universal rule of the whole kingdom, and is the law by which proceedings and determinations in the courts of justice are ordinarily directed. This for the most part settles the course of inheritance, the manner and form of acquiring and transferring property, the solemnities and obligations of contracts, the rules of expounding wills, deeds, and acts of parliament; the remedies of civil injuries, the different kinds of offences with the punishments allotted to each; the institution of four superior courts of record; and many other particulars which diffuse themselves as extensively as the distribution of common justice requires, all of which are not enacted by any particular statutes (though they are acknowledged by all) but depend entirely upon the common law.

2dly. Particular customs which concern the inhabitants of some particular district.

3dly. The third branch are those laws which are adopted by certain courts and jurisdictions, as the civil and canon laws.

The civil law is understood to signify the civil law of the Roman empire. The canon law is a body of Roman ecclesiastical law relating to matters over which the church exercises a jurisdiction. The civil law is used in four courts under certain restrictions, viz. the archbishops' and bishops' courts, usually styled curiæ christianitatis; the courts martial, the courts of admirality, and the courts of the two universities.

The second division of the laws of England are the statutes made by the king, lords, and commons, assembled in parliament. The oldest statute extant is the celebrated Magna Charta, 9 Hen. 3; though, doubtless, the records of many antecedent to that have been lost, and the maxims received as common law.

Statutes are general or special, public or private: general or public acts are those which concern the whole nation; of these the judges are obliged to take notice, though they should not be formally pleaded by the party who claims an advantage under them. Special or private acts are such as operate on private persons and concerns, which must be formally set forth by the party, or the judges are not obliged to notice them.

Statutes are either declaratory of the common law, where it is become disreputable, or fallen into disuse; or remedial, when made to supply the defects, or abridge the superfluities of the common law. These latter are subdivided into enlarging and restraining statutes, by enlarging the common law where it was too circumscribed, and restraining it where it was too luxuriant.

There is besides those grounds of the laws of England, a court of equity to moderate and explain them. (See Equity.) The courts of equity are, however, only had recourse to in matters of property; for their constitution will not permit, that in criminal cases any judge should have the power of construing the law otherwise than according to the letter. This caution, while it protects the public liberty, can never oppress the individual. A man cannot suffer more punishment than the law directs, but he may suffer less. The laws cannot be strained to inflict a penalty beyond what the letter warrants, but in cases where the letter induces any apparent hardship, the crown has power to pardon.

In treating of the laws, the best mode, and which has been adopted by sir William Blackstone in his excellent Commentaries, after the example of Wood in his Institutes, is to divide them, 1st, into the rights of persons, or the rights as to personal security, personal liberty, and private property. 2nd, The rights of things, or the rights which a man may acquire in and to such external things as are unconnected with his person. 3rd. Private wrongs, or such as are the infringement of the private rights of individuals: and 4th. public wrongs, or such as are a violation of the public rights, and affect the whole community.

It is of course unnecessary, and perhaps in a work of this nature irrelevant, to recommend the study of the law; it is sufficient to add the words of the great judge Blackstone on this subject. "It is incumbent (says he) upon every man to be acquainted with the laws, lest he incur the censure as well as the inconvenience of living in society without knowing the obligations it lays him under."

LAWSONIA, *Egyptian privet*, a genus of the monogynia order, in the octandria class of plants, and in the

natural method ranking with those of which the order is doubtful. The calyx is quadrifid; the petals four; the stamina four, in pairs; the capsule is quadrilocular and polyspermous. There are four species, all natives of India. Some authors take the inermis to be the plant termed by the Arabians henna or alhenna, the pulverised leaves of which are much used by the Eastern nations for dyeing their nails yellow; but others, Dr. Hasselquist in particular, attribute that effect to the leaves of the other species of Egyptian privet which bears prickly branches. It is probable that neither set of writers are mistaken, and that the shrub in question is a variety only of the thorny lawsonia, rendered mild by culture.

LAY-BROTHERS, among the Romanists, those pious, but illiterate persons, who devote themselves, in some convent, to the service of the religions. They wear a different habit from that of the religious, but never enter into the choir, nor are present at the chapters; nor do they make any other vow, except of constancy and obedience. In nunneries there are also lay-sisters.

Lay-man, among painters, a small statue either of wax or wood, whose joints are so formed, that it may be put into any attitude or posture. Its principal use is for adjusting the drapery in clothing of figures.

LAYERS, in gardening, are tender shoots or twigs of trees, laid or buried in the ground, till, having struck root, they are separated from the parent tree, and become distinct plants. The propagating trees by layers is done in the following manner: the branches of the trees are to be slit a little way, and laid under the mould for about half a foot: the ground should be first made very light, and after they are laid they should be gently watered. If they will not remain easily in the position they are put in, they must be pegged down with wooden hooks: the best season for doing this is, for evergreens, toward the end of August, and for other trees in the beginning of Feb. If they are found to have taken root, they are to be cut off from the main plant the succeeding winter, and planted out. If the branch is too high from the ground, a tub of earth is to be raised to a proper height for it. Some pare off the rind, and others twist the branch before they lay it: but this is not necessary. The end of the layer should be about a foot out of the ground; and the branch may be either tied tight round with a wire, or cut upwards from a joint, or cut round for an inch or two at the place, and it is a good method to pierce several holes through it with an awl above the part tied with the wire.

LAZAR-HOUSE, or **Lazaretto**, a public building, in the nature of an hospital, to receive the poor and those afflicted with contagious distempers: in some places lazarettos are appointed for the performance of quarantine; in which case, those are obliged to be confined in them who are suspected to have come from places infected with the plague. This is usually a large building, at some distance from a city, whose apartments stand detached from each other, where vessels are unladen, and the crew shut up for about 40 days, more or less, according to the time and place of their departure. The lazaretto of Milan is esteemed one of the finest hospitals in Italy.

LAZULITE. This stone, which is found chiefly in the northern parts of Asia, was long known to mineralogists by the name of lapis lazuli.

Lazulite is always amorphous. Its texture is earthy. Its fracture uneven. Lustre 0. Opaque, or nearly so. Hardness 8 to 9. Specific gravity 2.76 to 2.945. Colour blue; often spotted white from specks of quartz, and yellow from particles of pyrites.

It retains its colour at 100° Wedgewood; in a higher heat it intumesces, and melts into a yellowish-black mass. With acids it effervesces a little, and if previously calcined, forms with them a jelly.

Margraff published an analysis of lazulite in the Berlin Memoirs for 1758. His analysis has since been confirmed by Klaproth, who found a specimen of it to contain

46.0	silica
14.5	alumina
28.0	carbonat of lime
6.5	sulphat of lime
3.0	oxide of iron
2.0	water
100.0	

From the experiments of Morveau, it appears that the colouring matter of lazulite is sulphuret of iron.

LEAD, one of the perfect metals, appears to have been very early known. It is mentioned several times by Moses. The ancients seem to have considered it as nearly related to tin. It is of a bluish-white colour; and when newly melted is very bright, but it soon becomes tarnished by exposure to the air. It has scarcely any taste, but emits on friction a peculiar smell. It stains paper or the fingers a bluish colour. When taken internally, it acts as a poison. Its hardness is $5\frac{1}{2}$; its specific gravity is 11.3523. Its specific gravity is not increased by hammering, neither does it become harder, as is the case with the other metals; a proof that the hardness which metals assume under the hammer is in consequence of an increase of density. It is very malleable, and may be reduced to very thin plates by the hammer; it may be also drawn out into wire, but its ductility is not great. Its tenacity is such, that a lead wire only $\frac{1}{120}$ inch diameter is capable of supporting 18 pounds without breaking. It melts, according to sir Isaac Newton, when heated to the temperature of 540° Fahrenheit: but Morveau makes its fusing point as high as 594°. When a very strong heat is applied, the metal boils and evaporates. If it is cooled slowly, it crystallizes. The abbe Mongez obtained it in quadrangular pyramids, lying on one of their sides. Each pyramid was composed apparently of three layers. Pajot obtained it in the form of a polyhedron with 32 sides, formed by the concourse of six quadrangular pyramids.

When exposed to the air, it soon loses its lustre, and acquires first a dirty-grey colour, and at last its surface becomes almost white. This is owing to its gradual combination with oxygen, and conversion into an oxide; but this conversion is exceedingly slow; the external crust of oxide, which forms first, preserving the rest of the metal for a long time from the action of the air.

Water has no direct action upon lead; but it facilitates the action of the external air. For when lead is exposed to the air, and kept constantly wet, it is oxidated much more rapidly than it otherwise would be. Hence the rea-

son of the white crust which appears upon the sides of the leaden vessels containing water, just at the place where the upper surface of the water usually terminates.

No less than four different combinations of lead with oxygen are at present known, though some of them have not been examined with much attention.

1. The protoxide, or first oxide of lead, may be obtained by dissolving lead in nitric acid, and boiling the crystals which that solution yields by concentration along with pieces of metallic lead. The consequence is the formation of scaly crystals of a yellow colour, brilliant, and very soluble in water. These crystals are composed of the protoxide of lead combined with nitric acid. The protoxide may be precipitated by means of potass. Its properties have not hitherto been examined. It contains but a small proportion of oxygen.

2. The deutoxide of lead may be formed by dissolving the metal in nitric acid, and pouring potass into the solution. A yellow-coloured powder is obtained, which is the deutoxide of lead. This oxide is composed of 91 parts of lead, and 9 of oxygen. When lead is kept melted in an open vessel, its surface is soon covered with a grey-coloured pellicle. When this pellicle is removed, another succeeds it; and by continuing the heat, the whole of the lead may soon be converted into this substance. If these pellicles are heated and agitated for a short time in an open vessel, they assume the form of a greenish-grey powder. Mr. Proust has shown that this powder is a mixture of deutoxide, and a portion of lead in the metallic state. It owes its green colour to the blue and yellow powders which are mixed in it. If we continue to expose this powder to heat for some time longer in an open vessel, it absorbs more oxygen, assumes a yellow colour, and is then known in commerce by the name of massicot. The reason of this change is obvious. The metallic portion of the powder gradually absorbs oxygen, and the whole of course is converted into deutoxide.

When thin plates of lead are exposed to the vapour of warm vinegar, they are gradually corroded, and converted into a heavy white powder, used as a paint, and called white lead. This powder used formerly to be considered as a peculiar oxide of lead; but it is now known that it is a compound of the deutoxide and carbonic acid.

3. If massicot ground to a fine powder is put into a furnace, and constantly stirred while the flame of the burning coals plays against its surface, it is in about 48 hours converted into a beautiful red powder, known by the name of minium, or red lead. This powder, which is likewise used as a paint, and for various other purposes, is the tritoxide or red oxide of lead.

4. If nitric acid, of the specific gravity 1.260, is poured upon the red-coloured oxide of lead, 185 parts of the oxide are dissolved; but 15 parts remain in the state of a black, or rather deep-brown, powder. This is the peroxide, or brown oxide of lead, first discovered by Scheele. The best method of preparing it is the following, which was pointed out by Proust, and afterwards still farther improved by Vauquelin. Put a quantity of red oxide of lead into a vessel partly filled with water, and make oxymuriatic acid gas pass into it. The oxide becomes deeper and deeper coloured, and is at last dissolved. Pour potass into the solution, and the brown oxide of lead precipitates. By this process 68 parts of brown oxide may be obtained for every 100 of red oxide employed. This oxide is composed of about 79 parts of lead and 21 of oxygen. It is of a brilliant flea-brown colour. When heated it emits oxygen gas, becomes yellow, and melts into a kind of glass. When rubbed along with sulphur in a mortar, it sets the sulphur on fire, and causes it to burn with a brilliant flame. When heated on burning coals the lead is reduced. All the oxides of lead are very easily converted into glass; and in that state they oxidize and combine with almost all the other metals except gold, platinum, and silver. This property renders lead exceedingly useful in separating gold and silver from the baser metals with which they happen to be contaminated. The gold or silver to be purified is melted along with lead, and kept for some time in that state in a flat cup, called a cupel, made of burnt bones, or the ashes of wood. The lead is gradually vitrified, and sinks into the cupel, carrying along with it all the metals which were mixed with the silver and gold, and leaving these metals on the cupel in a state of purity. This process is called cupellation. The lead employed is afterwards extracted from the cupels, and is known in commerce by the name of litharge. It is a half-vitrified substance, of a high red colour, and composed of scales. It is merely an oxide of lead more or less contaminated with the oxides of other metals. But the best litharge is made by oxidizing lead directly, and then increasing the heat till the oxide is fused. The more violent the fusing heat, the whiter is the litharge.

Lead has not yet been combined with carbon, nor hydrogen; but it combines readily with sulphur and phosphorus.

1. Sulphuret of lead may be formed either by stratifying its two component parts, and melting them in a crucible, or by dropping sulphur at intervals on melted lead. The sulphuret of lead is brittle, brilliant, of a deep blue-grey colour, and much less fusible than lead. These two substances are often found naturally combined; the compound is then called galena, and is usually crystallized in cubes. Sulphuret of lead is composed, according to the experiment of Wenzel, of 86.8 parts of lead and 13.2 of sulphur.

2. Phosphuret of lead may be formed by mixing together equal parts of filings of lead and phosphoric glass, and then fusing them in a crucible. It may be cut with a knife, but separates into plates when hammered. It is of a silver-white colour with a shade of blue, but it soon tarnishes when exposed to the air. This phosphuret may also be formed by dropping phosphorus into melted lead. It is composed of about 12 parts of phosphorus, and 88 of lead.

Lead does not combine with azotic gas. Muriatic acid gradually corrodes it, and converts it into a white-coloured oxide.

Lead is capable of combining with most of the metals.

1. Lead may be easily alloyed with gold by fusion. The colour of the gold is injured, and its ductility diminished. This alloy is of no use; but it is often formed in order to purify gold by cupellation.

2. Platinum and lead unite in a strong heat: the alloy is brittle, of a purplish colour, and soon changes on ex-

posure to the air. Many experiments have been made with this alloy, in order, if possible, to purify platinum from other metals by cupellation, as is done successfully with silver and gold: but scarcely any of the experiments have succeeded; because platinum requires a much more violent heat to keep it in fusion than can be easily given.

3. Silver is often alloyed with lead in order to purify it by cupellation. This alloy is very fusible, much softer than silver, and has much less tenacity, elasticity, and sonorousness; its colour is nearly that of lead, and its specific gravity greater than the mean density of the metals alloyed.

4. Mercury amalgamates readily with lead in any proportion, either by triturating it with lead filings, or by pouring it upon melted lead. The amalgam is white and brilliant, and when the quantity of lead is sufficient, assumes a solid form. It is capable of crystallizing. The crystals are composed of one part of lead and one and a half of mercury.

5. Copper and lead may be easily combined by fusion. When the lead exceeds, the alloy is of a grey colour, and ductile while cold, but brittle when hot. It is employed sometimes for the purpose of making printer's types for very large characters.

6. It was formerly supposed that lead does not combine with iron; but the experiments of Guyton Morveau have proved, that when the two metals are melted together, two distinct alloys are formed. At the bottom is found a button of lead containing a little iron; above is the iron combined with a small portion of lead.

7. Lead and tin may be combined in any proportion by fusion. This alloy is harder, and possesses much more tenacity, than tin. Muschenbroeck informs us that these qualities are a maximum when the alloy is composed of three parts of tin and one of lead. What is called in this country ley pewter is often scarcely any thing else than this alloy. Tin foil too almost always is a compound of tin and lead. This alloy, in the proportion of two parts of lead and one of tin, is more soluble than either of the metals separately. It is accordingly used by plumbers as a solder.

The affinities of lead and of its oxide are as follow:

Lead.	Oxide of Lead.
Gold,	Sulphuric acid,
Silver,	Saciactic,
Copper,	Oxalic,
Mercury,	Arsenic,
Bismuth,	Tartaric,
Tin,	Muriatic,
Antimony,	Phosphoric,
Platinum,	Sulphurous,
Arsenic,	Suberic,
Zinc,	Nitric,
Nickel,	Fluoric,
Iron,	Citric,
Sulphur.	Lactic,
	Acetic,
	Boracic,
	Prussic,
	Carbonic.

Lead, *ores o*. Ores of lead occur in great abundance in almost every part of the world. They are generally in veins; sometimes in siliceous rocks, sometimes in calcareous rocks.

The following table exhibits a view of the different states in which this mineral has hitherto been observed.

I. Sulphurets.	III. Salts.
1. Galena,	1. Carbonat,
2. Blue lead ore,	2. Muriocarbonat,
3. Black ore of lead.	3. Sulphat,
	4. Phosphat,
II. Oxides	5. Molybdat,
1. Earthy ore of lead,	6. Arseniat?
2. Arseniated protoxide,	7. Arseniophosphat?
3. Arseniated peroxide.	8. Chromat.

Of these the first species is by far the most common. From it indeed almost the whole of the lead of commerce is extracted.

LEAF. See Botany.

Leaf-gold. See Aurum, Gold, Gilding, &c.

Leaf. See Architecture.

Leaf, in clocks and watches, an appellation given to the notches of their pinions. See Clockwork.

LEAGUE, a measure of length, containing more or less geometrical paces, according to the different usages and customs of countries. A league at sea, where it is chiefly used by us, being a land-measure mostly peculiar to the French and Germans, contains three thousand geometrical paces, or three English miles. The French league sometimes contains the same measure, and in some parts of France it consists of three thousand five hundred paces: the mean or common league consists of two thousand four hundred paces, and the little league of two thousand. The Spanish leagues are larger than the French, seventeen Spanish leagues making a degree, or twenty French leagues, or sixty-nine and a half English statute miles. The Dutch and German leagues contain each four geographical miles. The Persian leagues are pretty near of the same extent with the Spanish: that is, they are equal to four Italian miles, which is pretty near to what Herodotus calls the length of the Persian parasang, which contained thirty stadia, eight of which, according to Strabo, make a mile.

LEAK, among seamen, is a hole in the ship through which the water comes in. To spring a leak is said of a ship that begins to leak; to stop a leak, is to fill it with a plug wrapt in oakum and well tarred; or putting in a tarpaulin clout, to keep the water out; or nailing a piece of sheet-lead upon the place.

LEAKAGE, the state of a vessel that leaks, or lets water, or other liquid, ooze in or out. See the preceding article. Leakage, in commerce, is an allowance of 12 per cent. in the customs, allowed to importers of wines for the waste and damage it is supposed to have received in the passage; an allowance of two barrels in twenty-two is also made to the brewers of ale and beer, by the excise-office.

LEAP, in music. This word is properly applicable to any disjunct degree, but is generally used to signify a distance consisting of several intermediate intervals.

Leap-year. See Bissextile.

LEASE, a conveyance of lands, generally in consideration of rent or other annual recompence made for life,

for years, or at will, but always for a shorter term than the lessor has in the premises, otherwise it partakes more of the nature of an assignment.

By the common law, all persons seized of an estate might grant leases for any period less than their interest lasted; but statutes have been since made, some to enlarge and some to restrict it. They are divided into enabling and restricting statutes; by the enabling stat. 32 Henry VIII. c. 28. a tenant in tail may make leases to ensure for twenty-one years or three lives to bind his issue in tail, but not those in remainder or reversion. Husbands seized in right of their wives may make leases for the same period, provided the wife join in it. All persons seized of an estate of fee-simple in right of their churches, except parsons or vicars, may bind their successors under certain restrictions. 1. The lease must be by indenture; 2. It must begin from the day of making; 3. All old leases must be surrendered or be within a year of expiring; 4. It must be for three lives or twenty-one years, not both; 5. It may be for a shorter term, but must not exceed twenty-one years; 6. It must be of lands and tenements most commonly left for twenty years past; 7. The most usual rent for that time must be reserved; 8. Such leases cannot be made without impeachment of waste. It was also specified that the lease must be of corporal hereditaments, that the lessor might resort to them to distrain; but by stat. 5 Geo. III. c. 17, a lease of tithes or other incorporeal hereditaments may be granted, and the successor shall have his remedy by an action of debt.

From the disabling statutes, we find that all colleges, cathedrals, and other ecclesiastical or eleemosynary corporations, and all parsons and vicars, are restrained from making leases unless under the following regulations: 1. They must not exceed 3 lives or 21 years: 2. The accustomed rent must at least be reserved thereon: 3. Houses in corporations or market-towns may be let for 40 years, provided they are not the mansion-houses of the lessors, or have not more than 10 acres of ground belonging to them and provided the lessee agrees to keep them in repair, and they may be aliened in fee-simple for lands of equal value in recompense: 4. If there is an old lease which has more than 3 years to run, no new lease shall be made: 5. No lease shall be made without impeachment of waste: 6. All bounds and covenants tending to frustrate the provisions of the statutes of 13 and 18 Eliz. shall be void.

Two observations seem to present themselves concerning these statutes: 1. That they do not enable any persons to make such leases as they are by common law restrained from making; therefore, a parson or vicar, though he is restrained from making longer leases than for 21 years or 3 lives, even with the consent of the patron or ordinary, yet is not enabled to make any lease at all, to bind his successor without such consent. 2. Though leases contrary to these acts are void, yet they are good against the lessor during his life, if he is a sole corporation; and if it is an aggregate corporation, as long as the head lives: for the act was intended for the benefit of the successor alone, and it is a maxim of law that no man shall take advantage of his own wrong. With regard to college leases, one-third of the old rent must be reserved in wheat or malt, reserving a quarter of wheat for every 6s. 8d. and a quarter of malt for every 5s.; or the lessees must pay for the same, at the price of the market nearest the respective colleges on the market-day before the rent is due.

There are further restraining statutes which direct that if any beneficial clergyman is absent from his benefice above 80 days in the year, all leases and agreements made by him of the profits of his cure shall be void, except in the case of licensed pluralists; who are allowed to demise the living to the curate, if he is not absent more than 40 days in the year. See 13 Eliz. c. 20. 14 Eliz. c. 11, 18 Eliz. c. 11, and 43 Eliz. c. 9.

All leases except such as do not exceed 3 years from the making, whereupon the reserved rent must be at least two thirds of the improved value, must be in writing, though no particular form of words is necessary to constitute a good lease.

They must be made to natural-born subjects of this realm, or such as have been naturalized, or to denizens, for all leases made to aliens shall be void; and there is even a statute in force, 32 Hen. VIII. c. 16, which imposes a penalty of 5*l*. on the lessor and lessee. It has however been held that an alien merchant may take a house for his own residence, but it shall not go to his executors; the reasons for these laws are evidently to prevent foreigners getting too firm a footing in the kingdom.

Lease and *release* is a conveyance which since the stat. 27 Hen. VIII. c. 10, commonly called the statute of uses, has taken place of the deed of feoffment, as it supplies the need of livery and seisin. It is made thus: A lease or bargain and sale for one year, from the tenant to the lessee, is first prepared, whereby the lessee becomes actually possessed of the lands, then by the above mentioned statute the lessee is enabled to take a grant of the lands intended to be conveyed to him and his heirs for ever; accordingly a release is made, reciting the lease and declaring the uses. In the lease, a pepper-corn is a good consideration to make the lessee capable of receiving a release. This mode of conveyance is become so usual, that it merits peculiar attention. See this matter very ably discussed by the annotator of the latter part of Coke's Commentaries, p. 271, No. 1.

LEASES, *value of.* The purchaser of a lease may be considered as the purchaser of an annuity equal to the rack-rent of the estate; and the same principles, from which are deduced the present value of annuities to continue during any given term, will apply to the value of leases. The sum paid down for the grant of a lease is so much money paid in advance for the annual rents, as they may become due; or, it may be considered as a sum which put out to interest, will enable the lessor to repay himself the rack-rent of the estate, or the yearly value of his interest therein, during the given term; therefore no more money should be demanded by the lessor, for the grant of the lease, than will enable him to do this at a given rate of interest. In order to find what this sum should be it would be necessary to ascertain separately the present value of each annual rent, or the sum which, put out to interest at the given rate, will enable the landlord to repay himself the several yearly rents as they become due. Thus, if a person has 100*l*. due to him a twelvemonth hence, and he wishes to have the value of

LEDUM, marsh cistus, or wild rosemary; a genus of the monogynia order, in the decandria class of plants; and in the natural method ranking under the 18th order, bicornes. The calyx is quinquefid; the corolla plain and quinquepartite; the capsule quinquelocular, and opening at the base. There are three species: The palustre with very narrow leaves, grows naturally upon bogs and mosses in many parts of Yorkshire, Cheshire, and Lancashire. The flowers are produced in small clusters at the end of the branches, and are shaped like those of the strawberry-tree, but spread open wider at top. These are of a reddish colour, and in the natural places of their growth are succeeded by seed-vessels filled with small seeds which ripen in autumn.

LEE, in the sea-language, a word of various significations, though it is generally understood to mean the part opposite to the wind. Thus lee-shore, is that shore against which the wind blows. Lee-latch, or have a care of the lee-latch, is, take care that the ship don't go to the leeward, or too near the shore; a lee the helm, put it to the leeward side of the ship: to lie by the lee, or to come up to the lee, is to bring the ship so, that all her sails may lie flat against her masts and shrouds, and that the wind may come right upon her broadside.

Lee-fang, is a rope reeved into the cringles of the courses, to hale in the bottom of the sail, that the bonnets may be laced on, or the sail taken in.

Lee-way, is the angle that the rhumb-line upon which the ship endeavours to sail, makes with the rhumb upon which she really sails. See Navigation.

LEEA, a genus of the class and order pentandria monogynia. The calyx is one-petalled; necs. on the side of the corolla, upright, five-cleft; berry, five-seed. There are three species, trees of the East Indies.

LEECH. See Hirudo.

LEEK. See Allium.

LEERSIA, a genus of the class and order triandria digynia. Calyx none; glume, two-valved, closed. There are three species, grasses of America.

LEET, a little court held within a manor, and called the king's court, on account that its authority to punish offences originally belonged to the crown, whence it is derived to inferior persons. See Court.

LEETCH-lines, small ropes made fast to the leetch of the topsails, to which they belong, and reeved into a block at the yard close by the topsail-ties. They serve to hale in the leetch of the sail when the topsails are to be taken in.

LEGACY, a bequest of a sum of money, or any personal effects of a testator; and these are to be paid by his representative, after all the debts of the deceased are discharged, as far as the assets will extend.

All the goods and chattels of the deceased, are by law vested in the representative, who is bound to see whether there be left a sufficient fund to pay the debts of the testator, and if it should prove inadequate, the pecuniary legacies must proportionately abate; a specific legacy, however, is not to abate unless there be insufficient without it.

If the legatee die before the testator, such will in general be termed a lapsed legacy, and fall into the general fund; where however, from the general import of the will, it can be collected that the testator intended such a vested legacy, it will in such case go to the representative of the deceased legatee.

If a bequest be made to a person, if or when he attains a certain age, the legacy will be lapsed, if he die before he attain that age; but if such legacy may be made payable at that age, and the legatee die before that age, such legacy will be vested in his representative.

If in the latter case, the testator devise interest to be paid in the mean time, it will nevertheless be a vested legacy.

Where a legacy is bequeathed over to another, in case the first legatee die under a certain age, or the like, the legacy will be payable immediately on the death of the first legatee; and though such legacy be not bequeathed over, yet if it carry interest, the representative will become immediately entitled to it.

In case of a vested legacy due immediately, and charged on land, or money in the funds which yields an immediate profit, interest shall be payable from the death of the testator; but if it be charged on the personal estate only of the testator, which cannot be collected in, it will carry interest only from the end of the year after the death of the testator.

If a bequest be for necessaries, and of small amount, the executor will be justified in advancing a part of the principal; but this should be done under very particular circumspection, as the executor may be compelled to pay the full legacy on the infant's attaining his majority, without deducting the sum previously advanced.

When all the debts and particular legacies are discharged, the residue or surplus must be paid to the residuary legatee, if any be so appointed in the will; but if there be none appointed or intended, it will go to the executor or next of kin.

When the residue does not go to the executor, it is to be distributed among the intestate's next of kin, according to the statutes of distributions; except the same is otherwise disposable by particular customs, as those of London, York, &c. See Executor.

LEGATE, a cardinal or bishop, whom the pope sends as his ambassador to sovereign princes.

There are three kinds of legates, viz. legates a latere, legates de latere, and legates by office, or legati nati; of these the most considerable are the legates a latere, the next are the legates de latere.

Legates by office are those who have not any particular legation given them, but who by virtue of their dignity and rank in the church, become legates; such are the archbishops of Rheims and Arles; but the authority of these legates is much inferior to that of the legates a latere.

LEGATUS, in Roman antiquity, a military officer who commanded as deputy of the chief general.

LEGER-line, in music, one added to the staff of five lines, when the ascending or descending notes run very high or low.

LEGION, in Roman antiquity, a body of foot which consisted of ten cohorts.

The exact number contained in a legion, was fixed by Romulus at three thousand; though Plutarch assures us, that after the reception of the Sabines into Rome, he increased it to six thousand. The common number afterwards, in the first times of the free state, was four thou-

sand; but in the war with Hannibal, it arose to five thousand, and after this it is probable that it sunk again to four thousand, or four thousand two hundred, which was the number in the time of Polybius.

LEGNOTIS, a genus of the class and order polyandria monogynia. The calyx is five-cleft; pet. 5; caps. 3-celled. There are two species, trees of Jamaica and Guiana.

LEMMA, in mathematics, a proposition which serves previously to prepare the way for the more easy apprehension of the demonstration of some theorem, or construction of some problem.

LEMNA, a genus of the monœcia diandria class and order. The male cal. is one-leaved; cor. none; female, cal. one-leaved; cor. none; style one; caps. one-celled. There are six species, known by the name of duck-weed, or duck-meat.

LEMNISEA, a genus of the class and order polyandria monogynia. The cal. is 5-toothed; cor. 6-petalled, recurved; nect. cap-shaped, girding; the germ. per. 5-celled, seeds solitary. There is 1 species, a tree of Guiana.

LEMON. See CITRUS.

LEMON, *salt of.* See OXALAT *of potass.*

LEMUR, MACAUCO, a genus of quadrupeds of the order primates: the generic character is, front-teeth in the upper jaw, four; the intermediate ones remote: in the lower jaw, six; longer, stretched forwards, compressed, parallel, approximated. Canine-teeth solitary, approximated; grinders several, sublobated; the foremost somewhat longer and sharper.

The genus lemur or macauco consists of animals approaching to monkeys in the form of their feet, which, in most species, are furnished with flat nails; but differing in their manners, and void of that mischievous and petulant disposition which so much distinguishes the monkey tribe from other quadrupeds.

In this, as in the former genus, we meet with some species without a tail, while others have that part extremely long. Of the tailless species the most remarkable is the

1. Lemur tardigradus, slow lemur. It is about the size of a small cat, measuring sixteen inches in length; its colour is an elegant pale-brown or mouse-colour; the face flattish; the nose inclining to a sharpened form; the eyes yellow-brown, large, and extremely protuberant, so as to appear in the living animal like perfect hemispheres. They are surrounded by a circle of dark brown, which also runs down the back of the animal. This species is very slow in its motions, and from this circumstance has actually been ranked by some naturalists among the sloths; though in no other respect resembling them. It is a nocturnal animal, and sleeps, or at least lies motionless, during the greatest part of the day; its voice is shrill and plaintive.

2. Lemur indri. This is a very large species; it is entirely of a black colour, except on the face, which is greyish; a greyish cast also prevails towards the lower part of the abdomen, and the rump is white. The face is of a lengthened or dog-like form; the ears shortish and slightly tufted; the hair or fur is silky and thick, and in some parts of a curly or crisped appearance: it is the largest animal of this genus, and is said by Mons. Sonnerat, its first describer, to be three feet and a half high; it is said to be a gentle and docile animal, and to be trained, when taken young, for chace, in the manner of a dog. Its voice resembles the crying of an infant. It is a native of Madagascar, where it is known by the name of Indri, which is said to signify the man of the wood. The nails in this species are flat, but pointed at the ends; and there is no appearance of a tail.

3. Lemur macaco, ruffed lemur. This is the species described by the count de Buffon, under the name of the vari, its colours often consisting of a patched distribution of black and white; though its real or natural colour is supposed to be entirely black. In size it exceeds the mongos, or brown lemur. It is said to be a fierce and almost untameable animal: it inhabits the woods of Madagascar and some of the Indian islands; and is said to exert a voice so loud and powerful as to strike astonishment into those who hear it, resembling, in this respect, the howling monkey or S. Belzebub, which fills the woods of Brazil and Guiana with its dreadful cries. When in a state of captivity, however, it seems to become as gentle as some others of this genus.

The astonishing strength of voice in this animal, depends, according to the count de Buffon, on the peculiar structure of the larynx, which widens, immediately after its divarication, into a large cavity before entering the lungs.

4. Lemur tarsier. This animal is distinguished by the great length of its hind legs. Its general length from the nose to the tail is almost six inches; and from the nose to the hind toes eleven inches and a half; the tail nine inches and a half. The face is sharp or pointed; the eyes very large and full; the ears upright, broad, naked, and rounded. Between the ears on the top of the head is a tuft of long hairs. The colour of this species is grey-brown or mouse-colour, paler beneath. It is a native of Amboina and some other East India islands.

5. Lemur psilodactylus, long-fingered lemur. This highly singular species has so much the general appearance of a squirrel, that it has been referred to that genus both by Mr. Pennant in the last edition of his History of Quadrupeds, and by Gmelin in his enlarged edition of the Systema Naturæ of Linnæus. The account, however, given by Mons. Sonnerat, its first describer, seems to prove it a species of lemur. It measures from fourteen to eighteen inches from the nose to the tail, which is about the same length. The general colour of the animal is a pale ferruginous-brown, mixed with black and grey; on the head, round the eyes, and on the upper parts of the body, the ferruginous brown prevails, with a blackish cast on the back and limbs; the tail is entirely black; the sides of the head, the neck, the lower jaw, and the belly, are greyish. There are also a kind of woolly hairs of this colour, and of two or three inches in length, scattered over the whole body; the thighs and legs have a reddish cast; the black prevails on the feet, which are covered with short hairs of that colour; the head is shaped like that of a squirrel; and there are two cutting-teeth in front of each jaw; the ears are large, round, and naked, resembling those of a bat, and of a black colour. The feet are long, and somewhat resemble those of the Tarsier; the thumbs or interior toes of the hind feet are short, and furnished with flat round nails, as in the macaucos; but the principal character of the animal consists in the

village, of a young leveret suckled and nursed by a cat, which received it very early under her protection, and continued to guard it with maternal solicitude till it was grown to a considerable size.

A most singular variety of this animal is sometimes found, which is furnished with rough and slightly branched horns, bearing a considerable resemblance to those of a roebuck. This particularity, as strange as it is uncommon, seems to imply a kind of indistinct approach in this animal to the order pecora.

The hare is a short-lived animal, and is supposed rarely to exceed the term of seven or eight years.

It may be proper to add, that in very severe winters, and especially in those of the more northern regions, the hare becomes entirely white, in which state it is liable to be mistaken for the following species.

2. Lepus variabilis, varying hare. This species is an inhabitant of the loftiest alpine tracts in the northern regions of the globe; occurring in Norway, Lapland, Russia, Siberia, and Kamtschatka, and on the alps of Scotland. The same species is also found in America, appearing in some parts of Canada. In its general appearance it bears an extreme resemblance to the common hare, but is of smaller size, and has shorter ears and more slender legs. Its colour in summer is a tawny grey; in winter entirely white, except the tips of the ears, which are black; the soles of the feet are also black, but are very thickly covered with a yellowish fur. This animal is observed to confine itself altogether to elevated situations, and never to descend into the plains, or to mix with the common hare. The change of colour commences in the month of September, and the grey or summer coat reappears in April; but in the very severe climate of Siberia it continues white all the year round. It has been sometimes found entirely coal-black, a variety which is also known to take place occasionally in the common hare. The varying hare sometimes migrates in order to obtain food in severe seasons. Troops of five or six hundred have been seen to quit in this manner the frozen hills of Siberia, and to descend into the plains and woody districts, from which they again return in spring to the mountains.

3. Lepus Americanus, American hare. This animal is not much superior in size to a rabbit, measuring about eighteen inches. Its colour nearly resembles that of the common hare, to which it seems much allied: but the fore legs are shorter, and the hind ones longer in proportion. The belly is white; the tail black above and white beneath; the ears tipped with grey, and the legs of a pale-ferruginous colour. It is said to inhabit all parts of North America; and in the more temperate regions retains its colour all the year round, but in the colder parts becomes white in winter, when the fur grows extremely long and silvery; the edges of the ears alone retaining their former colour. It is said to be extremely common at Hudson's Bay, where it is considered as a highly useful article of food. It breeds once or twice a year, producing from five to seven at a time. It is not of a migratory nature, but always continues to haunt the same places, taking occasional refuge under the roots of trees, or in the hollows near their roots.

4. Lepus cuniculus, rabbit. The rabbit bears a very strong general resemblance to the hare, but is considerably smaller, and its fore feet are furnished with sharper and longer claws in proportion; thus enabling it to burrow in the ground, and to form convenient retreats, in which it conceals by day, and like the hare, comes out chiefly by night and during the early part of the morning to feed. Its colour, in the wild state, is a dusky brown, paler or whitish on the under parts, and the tail is black above and white below. In a domestic state the animal varies into black, black-and-white, silvery-grey, perfectly white, &c.

The rabbit is a native of most of the temperate and warmer parts of the old continent, but is not found in the northern regions, and is not originally a native of Britain, but was introduced from other countries. Its general residence is in dry, chalky, or gravelly soils, in which it can conveniently burrow. It is so prolific an animal that it has been known to breed seven times in a year, and to produce no less than eight young each time. It is therefore not surprising, that in some countries it has been considered as a kind of calamity, and that various arts of extirpation have been practised against it.

5. Lepus viscaccia. This species is said to have the general appearance of a rabbit, but has a long bushy and bristly tail, like that of a fox, which the animal also resembles in colour; the fur on all parts, except the tail, is soft, and is used by the Peruvians in the manufacture of hats; it was also used by the ancient Peruvians for the fabric of garments, worn only by persons of distinction. In its manners this animal resembles the rabbit, burrowing under ground, and forming a double mansion, in the upper of which it deposits its provisions, and sleeps in the other. It appears chiefly by night, and is said to defend itself when attacked by striking with its tail.

6. Lepus alpinus, alpine hare. This is a very different species from the alpine hare described by Mr. Pennant in the British Zoology, which is no other than the varying hare. The alpine hare is a far smaller animal, scarcely exceeding a guinea-pig (cavia cobaya) in size, and measuring only nine inches in length. Its colour is a bright ferruginous grey, paler beneath; the head is long, and the ears short, broad, and rounded. See Plate LXXVII. Nat. Hist. fig. 246. It appears to have been first described by Dr. Pallas, who informs us that it is a native of the Altaic mountains, and extends to the Lake Baikal, and even to Kamtschatka, inhabiting rough woody tracts amidst rocks and cataracts, and forming burrows beneath the rocks, or inhabiting the natural fissures, and dwelling sometimes singly, and sometimes two or three together. In their manners they greatly resemble some of the marmots or hamsters; preparing, during the autumn, a plentiful assortment of the finest herbs and grasses, which they collect in company, and after drying with great care in the sun, dispose into heaps of very considerable size, for their winter support; and which may always be distinguished, even through the deep snow, having the appearance of so many hay ricks in miniature, and being often several feet in height and breadth. The alpine hare varies in size according to the different regions in which it is found, being largest about the Altaic mountains, and smaller about Lake Baikal, &c.

7. Lepus ogotona, ogotona hare. This animal, says Dr. Pallas, is called by the Mongolians by the name of ogotona, and is an inhabitant of rocky mountains, or

sandy plains, burrowing under the soil, or concealing itself under heaps of stones, and forming a soft nest at no great depth from the surface. It wanders about chiefly by night, and sometimes appears by day, especially in cloudy weather. In autumn it collects heaps of various vegetables for its winter food, in the same manner as the alpine hare before described, disposing them into neat hemispherical heaps of about a foot in diameter. These heaps are prepared in the month of September, and are entirely consumed by the end of winter.

The ogotona hare is about six inches or somewhat more in length, and is of a pale brown colour above, and white beneath; on the nose is a yellowish spot, and the outsides of the limbs and space about the rump are of the same colour. It is entirely destitute of a tail. See Plate LXXVII. Nat. Hist. fig. 247.

8. Lepus pusillus, calling hare. In its form this species extremely resembles the ogotona hare, but is smaller, measuring near six inches, but weighing only from three ounces and a quarter to four and a half, and in winter two and a half. It is an inhabitant of the south-east parts of Russia, and about all the ridge of hills spreading southward from the Uralian chain; as well as about the Irtish, and the west part of the Altaic chain. It is an animal of a solitary disposition, and is very rarely to be seen, even in the places it most frequents.

Lepus, in astronomy, a constellation of the southern hemisphere, comprehending 12 stars according to Ptolemy; thirteen, according to Tycho; and nineteen in the Britannic catalogue.

LERCHEA, a genus of the class and order monadelphia pentandria. The cal. is five-toothed; cor. funnel-form, five-cleft; anthers, five; style, one; caps. three-celled, many-seeded. There is one species, a shrub of the East Indies.

LERNEA, in zoology; a genus of insects of the order of vermes mollusca, the characters of which are: the body fixes itself by its tentacula, is oblong, and rather tapering; there are two ovaries like tails, and the tentacula are shaped like arms. The cyprinacea has four tentacula, two of which are lunulated at the top. It is a small species, about half an inch long, and of the thickness of a small straw. It is found on the sides of the bream, carp, and roach, in many of our ponds and rivers, in great abundance. 2. The salmonea, or salmon-louse, has an ovated body, cordated thorax, and two linear arms, approaching nearly to each other. 3. The asellina, has a lunated body and cordated thorax; and inhabits the gills of the cod-fish and ling of the northern ocean.

LESKIA, a genus of the class and order cryptogamia musci; a moss of little note.

LESSOR and Lessee, in law. See Lease.

LET Fall, a word of command at sea, to put out a sail when the yard is aloft, and the sail is to come or fall down from the yard; but, in strictness, only applied to the main and fore courses, when their yards are hoisted up.

LETTER. A servant of the post-office is within the penalty of 5 Geo. III. c. 25, which makes it a capital felony to secrete a letter containing any bank note, though he has not taken the oath required by 9 Anne c. 10. But to secrete a letter containing money, is not an offence within the statutes concerning the servants of the post-office.

Letter *of credit*, is where a merchant or correspondent writes a letter to another, requesting him to credit the bearer with a certain sum of money.

Letter *of licence*, is a written permission granted to a person under embarrassment, allowing him to conduct his affairs for a certain time without being molested. Such instrument will bind all the creditors by whom it is executed, and it generally contains certain stipulations to be observed by all parties.

Letter *of attorney*, is an instrument giving to a second person the authority to do any lawful act in the stead of the maker. They are sometimes revokable and sometimes not; in the latter case the word irrevocable is inserted. The authority must be strictly pursued: and if the attorney does less than the power it shall be void; if more, it shall be good as far as the power goes, and void as to the rest; but both these rules have many exceptions. See 1 Inst. 258.

LETTERS. The rate of postage in the United States of every single letter is regulated by distance in the following proportions.

For any distance not exceeding 30 miles, 6 cents; 80 miles, 10 cents; 150 miles, $12\frac{1}{2}$ cents; 400 miles, $18\frac{1}{2}$ cents; and for any distance over 400 miles, 25 cents.

No allowance to be made for intermediate miles. Every double letter is to pay double the said rates; every triple letter, triple; every packet weighing one ounce or upwards, at the rate of four single letters each ounce. Every ship letter originally received at an office for delivery, 6 cents. Magazines and pamphlets, not over 50 miles, 1 cent per sheet; over 50 miles and not exceeding 100, $1\frac{1}{2}$ cents; over 100 miles, 2 cents. All letters or packets weighing not more than three pounds may be sent by the post; if heavier, at the discretion of the post-master general.

The master of every vessel arriving at any port in the United States where a post-office is established, before he is permitted to report, make entry, or break bulk, is bound to deliver to the post-master all letters directed to any person within the United States, which may be under his care or within his power, except such as are for the owner or consignee of the vessel, or are directed to be delivered at the port of delivery to which the vessel is bound, and he is to make oath or affirmation before the collector to that effect.

Letters, *threatening*. To send letters threatening to accuse a person of any crime punishable with death or any infamous punishment, and knowingly to send any anonymous or fictitious letter threatening to kill any one, or set fire to their tenements or property, with a view of extorting money or valuables from them, is in the first instance punishable with fine, pillory, whipping, or transportation for seven years, and in the other instance is felony without benefit of clergy.

Letters *patent*. See Patents, and Exemplification of Patents.

Letters, *close*, are grants of the king specially distinguished from letters patent, in that the letters close, being not of public concern, but directed to particular persons, are closed up and sealed.

LETTERS *of marque*, are extraordinary commissions, granted to captains or merchants for reprisals, in order to make a reparation for those damages they have sustained, or the goods they have been deprived of by strangers at sea.

These appear to be always joined to those of reprise, for the reparation of a private injury; but under a declared war the former only are required.

LETHARGY. See MEDICINE.

LEVARI FACIAS, is a writ directed to the sheriff for levying a certain sum of money upon the lands, &c. of a person who has forfeited his recognizance.

LEUCITE. This stone is usually found in volcanic productions, and is very abundant in the neighbourhood of Vesuvius. It is always crystallized. The primitive form of its crystals is either a cube or a rhomboidal dodecahedron, and its integrant molecules are tetrahedrons; but the varieties hitherto observed are all polyhedrons. The most common has a spheroidal figure, and is bounded by 24 equal and similar trapezoids; sometimes the faces are 12, 18, 36, 54, and triangular, pentagonal, &c. The crystals vary from the size of a pin's head to that of an inch.

The texture of the leucite is foliated; its fracture somewhat conchoidal; specific gravity from 2.455 to 2.490; colour white, or greyish white. Its powder causes syrup of violets to assume a green colour. Infusible by the blowpipe. Gives a white transparent glass with borax. It is composed, as Klaproth has shown of

54 silica
23 allumina
22 potass
—
99.

It was by analysing this stone that Klaproth discovered the presence of potass in the mineral kingdom, which is not the least important of the numerous discoveries of that accurate and illustrious chemist.

Leucite is found sometimes in rocks which have never been exposed to volcanic fire; and Mr. Dolomieu has rendered it probable, from the substances in which it is found, that the leucite of volcanoes has not been formed by volcanic fire, but that it existed previously in the rocks upon which the volcanoes have acted, and that it was thrown out unaltered in fragments of these rocks.

LEUCOJUM, *great snow-drop*, a genus of the monogynia order, in the hexandria class of plants, and in the natural method ranking under the ninth order, spathaceæ. The corolla is campanulated, sexpartite, the segments increased at the points, the stigma simple. The species are, 1. The vernum; or spring leucojum, has an oblong bulbous root, sending up a naked stalk, about a foot high, terminated by a spatha, protruding one or two white flowers, appearing in March. 2. The æstivum, or summer leucojum, has a large oblong bulbous root, an upright stalk, 15 or 18 inches high, terminated by many white flowers in May. 3. The autumnale has a large oblong bulbous root, narrow leaves, an upright stalk, terminated by white flowers in autumn. 4. The shumosum, with flowers white within, purplish without.

LEUCOMA. See SURGERY.

LEVEL, an instrument used to make a line parallel to the horizon, and to continue it out at pleasure; and by this means to find the true level, or the difference of ascent or descent, between two or more places, for conveying water, draining fens, &c.

There are several instruments, of different contrivance and matter, invented for the perfection of levelling; but they may be reduced to the following kinds.

Water-LEVEL; that which shows the horizontal line by means of a surface of water or other fluid, founded on this principle, that water always places itself level or horizontal.

The most simple kind is made of a long wooden trough or canal, which being equally filled with water, its surface shows the line of level.

The water-level is also made with two cups fitted to the two ends of a straight pipe, about an inch diameter, and three or four feet long, by means of which the water communicates from one cup to the other; and this pipe being moveable on its stand by means of a ball and socket, when the two cups show equally full of water, their two surfaces mark the line of level.

This instrument, instead of cups, may also be made with two short cylinders of glass three or four inches long, fastened to each extremity of the pipe with wax or mastic. The pipe is filled with common or coloured water, which show itself through the cylinders, by means of which the line of level is determined; the height of the water, with respect to the centre of the earth, being always the same in both cylinders. This level, though very simple, is yet very commodious for levelling small distances.

Air-LEVEL, that which shows the line of level by means of a bubble of air inclosed with some fluid in a glass tube of an indeterminate length and thickness, and having its two ends hermetically sealed. When the bubble fixes itself at a certain mark, made exactly in the middle of a tube, the case or ruler in which it is fixed is then level. When it is not level, the bubble will rise to one end. This glass tube may be set in another of brass, having an aperture in the middle, where the bubble of air may be observed. It should be filled with a liquid not liable to freeze or evaporate.

There is one of these instruments with sights, being an improvement upon that last described, which, by the addition of other apparatus, becomes more exact and commodious. It consists of an air-level (Plate LXXVIII. Miscel. fig. 146) about eight inches long, and about two-thirds of an inch in diameter, set in a brass tube 2, having an aperture in the middle C. The tubes are carried in a straight ruler, of a foot long; at the ends of which are fixed two sights 3, 3, exactly perpendicular to the tubes, and of an equal height, having a square hole, formed by two fillets of brass crossing each other at right angles; in the middle of this is drilled a very small hole, through which a point on a level with the instrument is seen. The brass tube is fastened to the ruler by means of two screws: the one of which, marked 4, serves to raise or depress the tube at pleasure, for bringing it towards a level. The top of the ball and socket is rivetted to a small ruler that springs, one end of which is fastened with springs, to the great ruler, and at the other end is a screw 5, serving to raise and depress the instrument when nearly level.

But this instrument is still less commodious than the

following one: for though the holes are ever so small, yet they will still take in too great a space to determine the point of level precisely.

Fig. 147. is a level with telescopic sights, first invented by Mr. Huygens. It is like the last, with this difference, that instead of plain sights it carries a telescope to determine exactly a point of level at a considerable distance. The screw 3, is for raising or lowering a little fork for carrying the hair, and making it agree with the bubble of air when the instrument is level; and the screw 4 is for making the bubble of air, D or E, agree with the telescope. The whole is fitted to a ball and socket, or otherwise moved by joints and screws. It may be observed, that a telescope may be added to any kind of level, or by applying it upon, or parallel to, the base or rule, when there is occasion to take the level of remote objects; and it possesses this advantage, that it may be inverted by turning the ruler and telescope half-round; and if then the hair cut the same point that it did before, the operation is just. Many varieties and improvements of this instrument have been made by the more modern opticians.

Dr. Desaguiliers proposed a machine for taking the difference of level, which contained the principles both of a barometer and thermometer; but it is not accurate in practice.

Reflecting Level, that made by means of a pretty long surface of water, representing the same object inverted, which we see erect by the eye; so that the point where these two objects appear to meet, is on a level with the place where the surface of the water is found.

There is another reflecting level, consisting of a polished metal mirror, placed a little before the object-glass of a telescope, suspended perpendicularly. This mirror must be set at an angle of 45 degrees; in which case the perpendicular line of the telescope becomes a horizontal line, or a line of level; which is the invention of M. Cassini.

Artillery Foot-Level, is in form of a square (fig. 148.), having its two legs or branches of an equal length; at the junction of which is a small hole, by which hangs a plummet playing on a perpendicular line in the middle of a quadrant, which is divided both ways from that point into 45 degrees.

This instrument may be used to other occasions by placing the ends of its two branches on a plane; for when the plummet plays perpendicularly over the middle division of the quadrant, the plane is then level.

To use it in gunnery, place the two ends on the piece of artillery, which may be raised to any proposed height by means of the plummet, which will cut the degree above the level. But this supposes the outside of the cannon is parallel to its axis, which is not always the case; and therefore they use another instrument now, either to set the piece level, or elevate it at any angle; namely, a small quadrant, with one of its radii continued out pretty long, which being put into the inside of the cylindrical bore, the plummet shows the angle of elevation, or the line of level.

Carpenter's, *Bricklayer's*, or *Pavior's* Level, consists of a long ruler, in the middle of which is fitted at right angles another broader piece, at the top of which is fastened a plummet, which when it hangs over the middle line of the second or upright piece, shows that the base or long ruler is horizontal or level. Fig. 149.

Mason's Level, is composed of three rulers, so jointed as to form an isoceles triangle, somewhat like a Roman A; from the vertex of which is suspended a plummet, which hangs directly over a mark in the middle of the base, when this is horizontal or level.

Plum or *Pendulum* Level, said to be invented by M. Picard, fig. 130. This shows the horizontal line by means of another line perpendicular to that described by a plummet or pendulum. This level consists of two legs or branches, joined at right angles, the one of which, of about 18 inches long, carries a thread and plummet; the thread being hung near the top of the branch, at the point 2. The middle of the branch where the thread passes is hollow, so that it may hang free from every where: but towards the bottom, where there is a small blade of silver, on which a line is drawn perpendicular to the telescope, the said cavity is covered by two pieces of brass, with a piece of glass G, to see the plummet through, forming a kind of case, to prevent the wind from agitating the thread. The telescope, of a proper length, is fixed to the other leg of the instrument, at right angles to the perpendicular, and having a hair stretched horizontally across the focus of the object-glass, which determines the point of level, when the string of the plummet hangs against the line on the silver blade. The whole is fixed by a ball and socket to its stand.

Fig. 151. is a *Balance* Level, which being suspended by the ring, the two sights, when in equilibrio, will be horizontal, or in a level.

But the most complete level is the *Spirits* Level, invented by the late Mr. Ramsden. See Plate LXXVI. Spirits Level. ABD, fig. 7. are the three legs upon which it is placed; when shut up, they form one round rod, and are kept together by three rings: these legs are jointed to a brass frame E, on the top of which is a male screw, screwing into a female screw within the projection *a* of the plate F. Within the top of *a*, figs. 4 and 7, is a hemispherical cavity to contain the spherical ball, fig. 5: this ball has a male screw *d* on its top, which screws into a female screw *b*, fig. 6, in the plate G, fig. 7 and fig. 6, the ball is put up through an opening *e*, fig. 4, and screwed to the plate, fig. 6; so that the upper plate G can move in any direction within certain limits by the play of the ball in its socket; to confine the upper plate G when it is set in any direction, four screws, HHHH, figs. 4 and 7, are employed; they work in tubes firmly fixed to the plate F, and are turned by their milled heads; the upper ends of these screws act against the under side of the plate, fig. 6, as shown in fig. 7; so that when the plate G is required to be moved in any direction, it is done by screwing up one screw and screwing down the opposite till it is brought to the proper inclination; then by screwing up both together, the plate is firmly fixed. The ball, fig. 5, has a conical hole *f* through it, to receive an axis which is screwed fast to the bottom of the compass-box I, fig. 7; a screw screwed into the end of this axis prevents its being lifted out, and at the same time leaves it at liberty to turn round independant of the ball, fig. 5. On each side of the compass-box I, is a bar KK, on the end of which are fixed two forked pieces 10, called the Y's (from their resemblance to that letter), carrying

the telescope M. One of these (O) is capable of being raised or lowered by means of a milled-headed screw N, which works through a collar in the lower end of the tube *g;* the rest of the tube has a triangular hole through it, in which slides a bar *k*, which is part of the Y; O the female screw is cut within this bar, and the screw works into it, so that by turning the milled head one way, the Y is raised, and by reversing the motion, it is lowered. The axis which connects the compass-box and the other apparatus, has a collar upon it just above where it enters the ball, fig. 5, which is embraced by a clamp P, fig. 6, which is closed by a screw C, so as to hold the collar of the axis quite tight; and when the screw is turned back, its own elasticity opens it so as to allow the axis of the compass-box to turn round freely within it; on the opposite side of the clamp is a projecting arm *l*, carrying the nut *m* of the screw Q, which screw works in a stud *n*, fixed to the upper plate G, figs. 7 and 6; by this means, when G is loosened, the telescope can be turned quite round, but when it is fastened, it can only be moved by turning the screw Q. The level-tube Z is fastened to the under side of the telescope by a screw *q* at one end and a bar *r* at the other: the use of these are to adjust it so that it shall be exactly parallel to the axis of the telescope-tube. The level, as best explained in the section, fig. 1, is a tube of glass *ss*, nearly filled with spirits of wine, but so as to leave a bubble of air in it; if the tube is of exactly the same diameter in every part, the bubble will rest in the middle of the tube when it is level. In some of the best levels made by Ramsden, the inside of the tube is bent into a segment of a circle, 100 feet diameter, and the inside is ground, which causes the bubble to adhere together; if the tube is straight, it is liable to divide into several small ones. The internal parts of the telescope are explained in fig. 1: RR is the external tube of brass plate; within this slides another tube *ss*; it has two glasses *v*, *w*, screwed into the outer end, called object-glasses, and it has two divisions *x*, *y*, called diaphagram, with small holes in them; their use is to collect the prismatic rays with which the objects would otherwise be tinged; the tube *ss* has a rack *t* fixed nearly in the middle of it, which takes into a pinion on the axis of the milled head T, figs. 1 and 7; by turning this, the glasses *v*, *w*, can be moved nearer to, or farther from, the eye to adjust the focus; to the tube R at *v* are fixed the cross wires, whose intersection is exactly in the centre of the tube. The manner of fixing these is explained in fig. 3: A is a brass box, which fits into the end of the telescope-tube, and is held there by four small screws; within this box is placed a brass plate B, carrying the wires, which are fastened by screwing four screws down upon their ends; when the plate B is in the box, a ring D is screwed in upon it, which prevents its falling out, but at the same time leaves it at liberty to move about in the box; the sides of the box, and also the telescope-tube, has four rectangular holes in it, through which four screws are passed into the edges of the piece B, so as to hold it in any position: these screws come through the external tube, and have square heads, to be turned by a key, so as to adjust the interactions in the centre: the box A has a female screw in the front, into which is screwed the eye-piece W; 3 is the tube which is screwed to the telescope; within this slides a tube, containing two glasses 4, 5; by sliding the glasses in or out of the tube 3, they can be adjusted so as to adopt their focus to the cross wires. This eye-piece is convenient on account of its shortness; but as it reverses the objects, it is sometimes more convenient to use the eye-piece fig. 2, which is much longer, but does not reverse objects. *a* is the tube which is screwed to the telescope; within this slides another tube *bb*, having at one end a tube *dd*, containing two glasses *ef*, and a diaphagram *g*, and at the other end a tube *hh*, containing two glasses *ik*, and a diaphagram: *m* is a cap screwed on to the end to prevent the tubes coming out. When the instrument is to be carried, the level is unscrewed from the legs and packed in a case; the legs are shut up and kept so by the rings, as before described. The manner of using this instrument is as follows: When the difference of level between any two places is required, the observer with the level goes to the highest of the two, and his assistant goes to the lowest with the target, which is a long pole of wood with a groove in it, in which slides a small rod carrying a round piece of wood, called a sight, which is to be observed through the telescope; the observer opens the legs of the instrument, and sets them on the ground; the level is next screwed to them at E, as shown in fig. 7; the telescope is then brought nearly to a level by the screws HHHH, as before described; the screw *c* is then turned so as to release the clamp P, fig. 6; and the telescope is turned about, so as to point to the target; the clamp P is then closed, the observer looks through the telescope, and by turning the nut T, the focus is adjusted: the screw Q is then turned till the cross wires are brought to coincide with the object, in an horizontal plane; he then takes his eye from the telescope, and works the screw N till he brings the bubble of air in the level-tube exactly in the middle, which shows that the telescope is perfectly horizontal; the observer then makes signals to the assistant to raise or lower the sight on the slider of the target, till it is brought to coincide with the intersection of the cross wire, which shows that the telescope and the sight of the target are on the same level; the height which the sight is from the ground where the target stands, deducted from the height the telescope stands from the ground, is the difference of level required.

LEVELLING, the art or act of finding a line parallel to the horizon at one or more stations, to determine the height or depth of one place with respect to another; for laying out grounds even, regulating descents, draining morasses, conducting water, &c.

Two or more places are on a true level when they are equally distant from the centre of the earth. Also one place is higher than another, or out of level with it, when it is farther from the centre of the earth; and a line equally distant from that centre in all its points, is called the line of true level. Hence, because the earth is round, that line must be a curve, and make a part of the earth's circumference, or at least parallel to it, or concentrical with it; as the line BCFG Plate LXXVIII. Misc. fig. 152), which has all its points equally distant from A, the centre of the earth, considering it as a perfect globe.

But the line of sight BDE, &c. given by the operations of levels, is a tangent, or a right line perpendicular to the semidiameter of the earth at the point of contact B, rising always higher above the true line of level, the farther the distance is, is called the apparent line of level.

Thus, CD is the height of the apparent level above the true level, at the distance BC or BD; also EF is the excess of height at F, and GH at G, &c. The difference, it is evident, is always equal to the excess of the secant of the arch of distance above the radius of the earth.

The common methods of levelling are sufficient for laying pavements of walks, or for conveying water to small distances, &c.; but in more extensive operations, as in levelling the bottoms of canals, which are to convey water to the distance of many miles, and such like, the difference between the true and the apparent level must be taken into the account.

Now the difference CD between the true and apparent level, at any distance BC or BD, may be found thus: By a well-known property of the circle, 2AC + CD : BD : : BD : CD; or because the diameter of the earth is so great with respect to the line CD at all distances to which an operation of levelling commonly extends, that 2AC may be safely taken for 2AC + CD in that proportion without any sensible error, it will be 2AC : BD : : BD : CD, which therefore is $= \frac{BD^2}{2AC}$, or $\frac{BC^2}{2AC}$ nearly; that is, the difference between the true and apparent level, is equal to the square of the distance between the places, divided by the diameter of the earth; and consequently it is always proportional to the square of the distance.

Now the diameter of the earth being nearly 7958 miles; if we first take BC = 1 mile, then the excess $\frac{BC^2}{2AC}$ becomes $\frac{1}{7958}$ of a mile, which is 7.962 inches, or almost 8 inches, for the height of the apparent above the true level at the distance of one mile. Hence, proportioning the excesses in altitude according to the squares of the distances, the following Table is obtained, showing the height of the apparent above the true level for every 100 yards of distance on the one hand, and for every mile on the other.

Dist. or BC.	Dif. of Level, or CD.	Dist. or BC.	Dif of Level, or CD.	
Yards	Inches.	Miles.	Feet.	Inc.
100	0.026	$\frac{1}{4}$	0	$0\frac{1}{2}$
200	0.103	$\frac{1}{2}$	0	2
300	0.231	$\frac{3}{4}$	0	$4\frac{1}{2}$
400	0.411	1	0	8
500	0.643	2	2	8
600	0.925	3	6	0
700	1.260	4	10	7
800	1.645	5	16	7
900	2.081	6	23	11
1000	2.570	7	32	6
1100	3.110	8	42	6
1200	3.701	9	53	9
1300	4.344	10	66	4
1400	5.038	11	80	3
1500	5.784	12	95	7
1600	6.580	13	112	2
1700	7.425	14	130	1

By means of tables of reductions, we can now level to almost any distance at one operation, which the ancients could not do but by a great multitude; for, being unacquainted with the correction answering to any distance, they only levelled from one 20 yards to another, when they had occasion to continue the work to some considerable extent.

This table will answer several useful purposes. Thus, first, to find the height of the apparent level above the true, at any distance. If the given distance is in the table, the correction of level is found on the same line with it: thus at the distance of 1000 yards, the correction is 2.57, or two inches and a half nearly; and at the distance of 10 miles, it is 66 feet 4 inches. But if the exact distance is not found in the table, then multiply the square of the distance in yards by 2.57 and divide by 1,000,000, or cut off six places on the right for decimals; the rest are inches: or multiply the square of the distance in miles by 66 feet 4 inches, and divide by 100.

2dly, To find the extent of the visible horison, or how far can be seen from any given height, on a horizontal plane, as at sea, &c. Suppose the eye of an observer, on the top of a ship's mast at sea, is at the height of 130 feet above the water, he will then see about 14 miles all around. Or from the top of a cliff by the sea-side, the height of which is 66 feet, a person may see to the distance of near 10 miles on the surface of the sea. Also, when the top of a hill, or the light in a light-house, or such like, whose height is 130 feet, first comes into the view of an eye on board a ship, the table shows that the distance of the ship from it is 14 miles, if the eye is at the surface of the water; but if the height of the eye in the ship is 80 feet, then the distance will be increased by near 11 miles, making in all about 25 miles distance.

3dly, Suppose a spring to be on one side of a hill, and a house on an opposite hill. with a valley between them, and that the spring seen from the house appears by a levelling instrument to be on a level with the foundation of the house, which suppose is at a mile distance from it; then is the spring eight inches above the true level of the house; and this difference would be barely sufficient for the water to be brought in pipes from the spring to the house, the pipes being laid all the way in the ground.

4th, If the height or distance exceed the limits of the table, then, first, if the distance be given. divide it by 2, or by 3, or by 4, &c. till the quotient come within the distances in the table; then take out the height answering to the quotient, and multiply it by the square of the divisor, that is, by 4, or 9, or 16, &c. for the height required: so if the top of a hill is just seen at the distance of 40 miles, then 40 divided by 4 gives 10, to which in the table answer $66\frac{1}{3}$ feet. which being multiplied by 16, the square of 4, gives $1061\frac{1}{3}$ feet for the height of the hill. But when the height is given. divide it by one of these square numbers 4, 9, 16, 25. &c. till the quotient come within the limits of the table, and multiply the quotient by the square root of the divisor, that is by 2. or 3, or 4, or 5, &c. for the distance sought: so when the top of the peak of Teneriffe, said to be almost 3 miles, or 15840 feet high, just comes into view at sea, divide 15840 by 225, or the square of 15, and the quotient is 70 nearly: to which in the table answers by proportion nearly $10\frac{2}{7}$ miles; then multiplying $10\frac{2}{7}$ by 15, gives 154 miles and $\frac{2}{7}$, for the distance of the hill.

The operation of levelling is as follows: Suppose the height of the point A (Plate LXXVIII. Misc. fig. 153,) on the top of a mountain, above that of B at the foot of it, is required. Place the level about the middle distance at D, and set up pickets, poles, or staffs at A and B, where persons must attend with signals for raising and lowering, on the said poles, little marks of pasteboard or other matter. The level having been placed horizontally by the bubble, &c. look towards the staff AE, and cause the person there to raise or lower the mark till it appears through the telescope or sights, &c. at E: then measure exactly the perpendicular height of the point E above the point A, which suppose 5 feet 8 inches, and set it down in your book. Then turn your view the other way towards the pole B, and cause the person there to raise or lower his mark, till it appears in the visual line as before at C; and measuring the height of C above B, which suppose 15 feet 6 inches, set this down in your book also, immediately above the number of the first observation. Then subtract the one from the other, and the remainder 9 feet 10 inches will be the difference of level between A and B, or the height of the point A above the point B.

If the point D, where the instrument is fixed, is exactly in the middle between the points A and B, there will be no necessity for reducing the apparent level to the true one, the visual ray on both sides being raised equally above the true level. But if not, each height must be corrected or reduced according to its distance, before the one corrected height is subtracted from the other.

When the distance is very considerable or irregular, so that the operation cannot be effected at once placing of the level, or when it is required to know if there is a sufficient descent for conveying water from the spring A to the point B (fig. 154.), this must be performed at several operations. Having chosen a proper place for the first station, as at I, fix a pole at the point A near the spring, with a proper mark to slide up and down it, as L; and measure the distance from A to I. Then the level being adjusted in the point T, let the mark L be raised or lowered till it is seen through the telescope or sights of the level. and measure the height AL. Then having fixed another pole at H, direct the level to it, and cause the mark G to be moved up or down till it appears through the instrument; then measure the height GH, and the distance from I to H, noting them down in the book. This done, remove the level forwards to some other eminence as E, from whence the pole H may be viewed, as also another pole at D; then having adjusted the level in the point E, look back to the pole H; and managing the mark as before, the visual ray will give the point F; then measuring the distance HE and the height HF, note them down in the book. Then, turning the level to look at the next pole D, the visual ray will give the point D; there measure the height of D. and the distance EB, entering them in the book as before. And thus proceed from one station to another till the whole is completed.

But all these heights must be corrected or reduced by the foregoing table, according to their respective distances and heights, with their corrections entered in the book, in the following manner:

Back-sights.					Fore-sights.				
Dists.	Hts.			Cors	Dists.	Hts.			Cors
yds		ft.	in.	inc.	yds.		ft.	in.	inc.
IA 1650	AL	11	3	7.0	IH 1265	HG	19	5	4.0
EH 940	HF	10	7	2.2	EB 900	BD	8	1	2.1
2590		21	10	9.2	2165		27	6	6.1
			9.2		2590			6.1	
		21	0.8		Dist. 4755		26	11.9	
							21	0.8	
					Whole dif. of level		5	11.1	

Having summed up all the columns, add those of the distances together, and the whole distance from A to B is 4755 yards, or two miles and three quarters nearly. Then the sums of the corrections taken from the sums of the apparent heights, leave the two corrected heights; the one of which being taken from the other, leaves 5 feet 11.1 inches for the true difference of level sought between the two places A and B, which is at the rate of an inch and a half nearly to every 100 yards, a quantity more than sufficient to cause the water to run from the spring to the house.

Or the operation may be otherwise performed, thus: Instead of placing the level between every two poles, and taking both back-sights and fore-sights, plant it first at the spring A, and from thence observe the level to the first pole; then move it to this pole, and observe the second pole; next remove it to the second pole, and observe the third pole; and so on, from one pole to another, always taking foreward sights or observations only. And then at the last, add all the corrected heights together, and the sum will be the whole difference of level sought.

Levelling-staves, instruments used in levelling, serving to carry the marks to be observed, and at the same time to measure the heights of those marks from the ground. They usually consist each of two long wooden rulers, made to slide over one another, and divided into feet, inches, &c.

LEVER. See Mechanics.

LEVIGATION. See Pharmacy.

LEVISANUS, a genus of the class and order pentandria monogynia. The flowers are aggregate; corolla one-leafed, superior, five-cleft; filaments inserted into the base of the perianthium; styles two, conjoined; seeds five or six. There are five species, shrubs of the Cape.

LEYDEN PHIAL. See Electricity.

LEYSERA, a genus of the polygamia superflua order, in the syngenesia clase of plants, and in the natural method ranking under the 49th order, compositæ. The receptacle is naked; the pappus paleaceous; that of the disc plumy; the calyx scarious. There are three species, shrubs of the Cape.

LIATRIS, a genus of the class and order syngenesia polygamia æqualis. The calyx is oblong, imbricate, awnless, coloured down, feathered coloured; receptacle naked,

hollow dotted. There are eight species, herbs of America.

LIBEL, injurious reproaches or accusations written and published against the memory of one who is dead, or the reputation of one who is alive, and thereby exposing him to public hatred, contempt, and ridicule.

With regard to libels in general, there are, as in many other cases, two remedies; one by indictment or inforformation, and the other by action. The former for a public offence; for every libel has a tendency to the breach of the peace, by provoking the person libelled to break it; which offence is said to be the same in point of law, whether the matter contained is true or false; and therefore it is that the defendant on an indictment for publishing a libel, is not allowed to allege the truth of it by way of justification. But in the remedy by action on the case, which is to repair the party in damages for the injury done him, the defendant may, as for words spoken, justify the truth of the facts, and show that the plaintiff has received no injury at all. The chief excellence therefore of a civil action for a libel consists in this, that it not only affords a reparation for the injury sustained, but is a full vindication of the innocence of the person traduced. 3 Black. 125.

By a late statute, the jury are acknowledged to be judges both of the law and the fact.

Libel, in the ecclesiastical court, is the declaration or charge drawn up in writing, on the part of the plaintiff, to which the defendant is obliged to answer.

Libel, in the law of Scotland, signifies an indictment.

LIBELLULA, *dragon-fly*, a genus of insects of the order neuroptera. The generic character is: mouth furnished with several jaws; antennæ very short; wings four, extended; tail (in the male) hook-forcipated.

The libellulæ, or dragon-flies, sometimes called by the very improper title of horse-stingers, exhibit an instance scarcely less striking than the butterfly of that strange dissimilitude in point of form under which one and the same animal is destined to appear in the different periods of its existence. Perhaps few persons not particularly conversant in the history of insects, would imagine that these highly brilliant and lively animals, which may be seen flying with such strength and rapidity round the meadows, and pursuing the smaller insects with the velocity of a hawk, had once been inhabitants of the water, and that they had resided for a long space of time in that element before they assumed their flying form. Of the libellulæ there are many different species, both native and exotic. The most remarkable of the English species is the libellula varia, or great variegated libellula. This insect makes its appearance principally towards the decline of summer, and is an animal of singular beauty: its general length is about three inches from head to tail, and the wings, when expanded, measure near four inches from tip to tip; the head is very large, and affixed to the thorax by an extremely slender neck; the eyes occupy by far the greatest part of the head, and are of a pearly blue-grey cast, with a varying lustre; the front is greenish yellow; the thorax of the same colour, but marked by longitudinal black streaks; the body, which is very long, slender, and subcylindrical, is black, with rich variegations of bright blue, and deep grass-green; the wings are perfectly transparent, strengthened by very numerous black retigular fibres, and exhibit a strongly iridescent appearance, according to the various inflexions of light; each is marked near the tip by a small oblong square black spot on the outer edge; the legs are black, and the tail is terminated by a pair of black forcipated processes, with an intermediate shorter one of similar colour. Sometimes this insect varies; the spots or marks on the abdomen and thorax being red or red-brown instead of green.

The female libellula deposits or drops her eggs into the water, which sinking to the bottom, are hatched, after a certain period, into hexapode flattish larvæ or caterpillars, of a very singular and disagreeable aspect. They cast their skins several times before they arrive at their full size, and are of a dusky-brown colour. The rudiments of the future wings appear on the back of such as are advanced to what may be called the pupa or chrysalis state, in the form of a pair of oblong scales or processes, and the head is armed with a most singular organ for seizing its prey, viz. a kind of proboscis, of a flattened form, and furnished with a joint in the middle, the end being much dilated, and armed with a pair of strong hooks or prongs. This proboscis, when the animal is at rest, is folded or turned up in such a manner as to lap over the face like a mask; but when the creature sees any insect which it means to attack, it springs suddenly forwards, and by stretching forth the jointed proboscis, readily obtains its prey. They continue in this their larva and pupa state for two years, when, having attained their full size, they prepare for their ultimate change; and creeping up the stem of some water-plant, and grasping it with their feet, they make an effort, by which the skin of the back and head is forced open, and the inclosed libellula gradually emerges. The wings, at this early period of exclusion, like those of butterflies, are very short, tender and contracted, all the ramifications of fibres having been compressed within the small compass of the oblong scales on the back of the larva, or pupa; but in the space of about half an hour, they are fully expanded, and have acquired the solidity and strength necessary for flight. This curious process of the evolution or birth of the libellula generally takes place in the morning, and during a clear sunshine. The remaining part of the animal's life is but short in comparison with that which it passed in its aquatic state, the frosts of the close of autumn destroying the whole race. They are also the prey of several sorts of birds.

The libellula depressa is a smaller or shorter species than the preceding, though with a considerably broader body in proportion. The male is of a bright sky-blue, with the sides of the body yellow; the female of a fine brown or bay, with yellow sides also. The wings in both sexes are transparent, except at the shoulders, where they are each marked by a broad bed or patch of brown with a stripe of yellow; the tips of each wing have also a small oblong-square black spot on the outer margin. The larva of this species is of a shorter form than that of the preceding, and is of a greenish-brown colour.

The libellula virgo is one of the most elegant of the European insects. It is much smaller than the libellula varia, and is distinguished by its very slender, long, cylindric body, which, as well as the head and thorax, is usually either of a bright but deep golden green, or else

of a deep gilded blue. The wings are transparent at the base and tips, but are each marked in the middle by a very large oval patch or bed of deep blackish or violet blue, accompanied with iridescent hues according to the direction of the light: sometimes the wings are entirely violet-black, without the least appearance of transparency either at the base or tips; and sometimes they are altogether transparent, without any appearance of the violet-black patch which distinguishes the majority of specimens; and lastly the insect sometimes appears with transparent wings, but shaded with a strong cast of gilded greenish brown, each being marked by a small white speck at the exterior edge, near the tip.

A much smaller species than the preceding, and equally common, is the libellula puella of Linnæus. This varies much in colour, but is generally of a bright and beautiful sky-blue, variegated with black bars on the joints, and with the thorax marked by black longitudinal stripes. The wings are transparent, and each marked near the tip with a small oblong-square black marginal spot.

The exotic libellulæ are very numerous. Among the most remarkable may be numbered the L. lucretia. It is a native of the Cape of Good Hope, and is distinguished by the excessive length of its slender body, which measures not less than five inches and a half in length, though scarcely exceeding the tenth of an inch in diameter. The wings are transparent, of a slender or narrow shape, as in the L. puella, to which this species is allied in form, and measure five inches and a half in extent from tip to tip. The colour of the head and thorax is brown, with a yellowish stripe on each side, and the body is of a deep mazarine-blue. See Plate LXXVII. Nat. Hist. figs. 250, 251.

LIBERTUS, in Roman antiquity, a person who from being a slave, had obtained his freedom. The difference between the liberti and libertini was this: the liberti were such as had been actually made free themselves, and the libertini were the children of such persons.

LIBRA, *the balance*, in astronomy, one of the twelve signs of the zodiac, the sixth in order; so called because when the sun enters it, the days and nights are equal, as if weighed in a balance.

Authors enumerate from ten to forty-nine stars in this sign.

Libra, in Roman antiquity, a pound weight; also a coin, equal in value to twenty denarii.

LIBRATION, in astronomy, an apparent irregularity of the moon's motion, whereby she seems to librate about her axis, sometimes from the east to the west, and now and then from the west to the east; so that the parts in the western limb or margin of the moon sometimes recede from the centre of the disk, and sometimes move towards it, by which means they become alternately visible and invisible to the inhabitants of the earth.

Libration *of the earth*, is sometimes used to denote the parallelism of the earth's axis, in every part of its orbit round the sun.

LICENCE, in law, an authority given to a person to do some lawful act.

A licence is a personal power, and therefore cannot be transferred to another. If the person licensed abuse the power given him, in that case he becomes a tresspasser.

LICENTIATE, one who has obtained the degree of a licence. The greatest number of the officers of justice in Spain are distinguished by no other title but that of licentiate. In order to pass licentiate in common law, civil law, and physic, they must have studied seven years; and in divinity, ten. Among us, a licentiate usually means a physician who has a licence to practise, granted by the college of physicians, or the bishop of the diocese.

LICHEN, *liverwort*, a genus of the natural order of algæ, in the cryptogamia class of plants. The male receptacle is roundish, somewhat plain and shining. In the female the leaves have a farina or mealy substance scattered over them. There are about 216 species, all found in Britain. Among the most remarkable are the following:

1. The geographicus; it is frequent in rocks, and may be readily distinguished at a distance. The crust or ground is of a bright greenish-yellow colour, sprinkled over with numerous plain black tubercles; which frequently run into one another, and form lines resembling the rivers in a map, from which last circumstance it takes it name.

2. The calcareous, or black-nobbed dyer's lichen, is frequent on calcareous rocks; and has a hard, smooth, white, stony, or tartareous crust, cracked or tesselated on the surface, with black tubercles. Dillenius relates, that this species is used in dyeing, in the same manner as the tartareous after-mentioned.

3. The ventosus, or red spangled tartareous lichen, has a hard tartareous crust, cracked and tesselated on the surface, of a pale yellow colour when fresh, and a light olive when dry. The tubercles are of a blood-red colour at top, their margin and base of the same colour as the crust. The texture and appearance of this (according to Mr. Lightfoot) indicate that it would answer the purposes of dyeing as well as some others of this tribe, if proper experiments were made.

4. The candelarius, or yellow farinaceous lichen, is common upon walls, rocks, boards, and old pales. There are two varieties. The first has a farinaceous crust of no regular figure, covered with numerous small greenish-yellow or olive shields, and grows commonly upon old boards. The other has a smooth, hard, circular crust, wrinkled and lobed at the circumference, which adheres closely to rocks and stones. In the centre are numerous shields of a deeper yellow or orange colour, which, as they grow old, swell in the middle, and assume the figure of tubercles. The inhabitants of Smaland in Sweden scrape this lichen from the rocks, and mix it with their tallow, to make golden candles to burn on festival days.

5. The tartareus, or large yellow-saucered dyer's lichen, is frequent on rocks, both in the Highlands and Lowlands of Scotland. The crust is thick and tough, either white or greenish white, and has a rough watered surface. The shields are yellow or buff-coloured, of various sizes; from that of a pin's head to the diameter of a silver penny. Their margins are of the same colour as the crust. This lichen is much used by the Highlanders for dyeing a fine claret or pompadour colour. For this purpose, after scraping it from the rocks, and cleaning it, they steep it in urine for a quarter of a year. Then taking it out, they make it into cakes, and hang them up in bags to dry. These cakes are afterwards pulverised,

and the powder is used to impart the colour with an addition of alum.

6. The parellus, or crawfish-eye lichen, grows upon walls and rocks, but is not very common. The crusts spread closely upon the place where they grow, and cover them to a considerable extent. They are rough, tartareous, and ash-coloured, of a tough coriaceous substance. The shields are numerous and crowded, having white or ash-coloured, shallow, plain discs, with obtuse margins. This is used by the French for dyeing a red colour.

7. The saxatilis, or grey-blue pitted lichen, is very common upon trunks of trees, rocks, tiles, and old wood. It forms a circle two or three inches diameter. The upper surface is of a blue grey, and sometimes of a whitish ash-colour, uneven, and full of numerous small pits or cavities; the under side is black, and covered all over, even to the edges, with short simple hairs or radicles. A variety sometimes occurs with the leaves tinged of a red or purple colour. This is used by finches and other small birds in constructing the outside of their curiously formed nests.

8. The omphalodes, or dark-coloured dyer's lichen, is frequent upon rocks. It forms a thick widely expanded crust of no regular figure, composed of numerous imbricated leaves of a brown or dark-purple colour, divided into small segments. The margins of the shields are a little crisped and turned inwards, and their outside ash-coloured. This lichen is much used by the Highlanders in dyeing a reddish-brown colour. They steep it in urine for a considerable time, till it becomes soft and like a paste; then, forming the paste into cakes, they dry them in the sun, and preserve them for use in the manner already related of the tartareous.

9. The parietinus or common yellow wall-lichen, is very common upon walls, rocks, tiles of houses, and trunks of trees. It generally spreads itself in circles of two or three inches diameter, and is said to dye a good yellow or orange-colour with alum.

10. The Islandicus, or eatable Iceland lichen, grows on many mountains both of the Highlands and Lowlands of Scotland. It consists of nearly erect leaves about two inches high, of a stiff substance when dry, but soft and pliant when moist, variously divided without order into broad distant segments, befid or trifid at the extremities. The upper or interior surface of the leaves is concave, chesnut-colour, smooth, and shining, but red at the base; the under or exterior surface is smooth and whitish, a little pitted, and sprinkled with very minute black warts. The margins of the leaves and all the segments from bottom to top, are ciliated with small, short, stiff, hair-like spinules, of a dark chesnut-colour, turning towards the upper side. The shields are very rarely produced. Made into broth or gruel, it is said to be very serviceable in coughs and consumptions; and, according to Haller and Scopoli, is much used in these complaints in Vienna.

11. The pulmonareous, or lung-wort lichen, grows in shady woods upon the trunks of old trees. The leaves are as broad as a man's hand, of a kind of leather-like substance, hanging loose from the trunk on which it grows, and lacinated into wide angular segments. Their natural colour, when fresh, is green: but in drying, they turn first to a glauceous and afterwards to a fuscous colour. It has an astringent, bitter taste; and, according to Gmelin, is boiled in ale in Siberia, instead of hops. The ancients used it in coughs and asthmas, &c. but it is not used in modern practice.

12. The calicaris, or beaked lichen, grows sometimes upon trees, but more frequently upon rocks, especially on the sea-coasts, but is not very common. It is smooth, glossy, and whitish, producing flat or convex shields, of the same colour as the leaves, very near the summits of the segments, which are acute and rigid, and, being often reflected from the perpendicular by the growth of the shields, appear from under their limbs like a hooked beak. This will dye a red colour; and promises, in that intention, to rival the famous lichen rocolla or argol, which is brought from the Canary Islands, and sometimes sold at the price of 80*l.* per ton. It was formerly used instead of starch to make hair-powder.

13. The prunastri, or common ragged hoary lichen, grows upon all sorts of trees; but it is generally most white and hoary on the sloe and old palm trees, or upon old pales. This is the most variable of the whole tribe of lichens, appearing different in figure, magnitude, and colour, according to its age, place of growth, and sex. The young plants are of a glaucous colour, slightly divided into small acute crested segments. As they grow older, they are divided like a stag's horn, into more and deeper segments, somewhat broad, flat, soft, and pitted on both sides, the upper surface of a glaucous colour, the under one white and hoary. The male plants, as Linnæus terms them, are short, seldom more than an inch high, not hoary on the under side; and have pale glaucous shields situated at the extremities of the segments, standing on short peduncles, which are only small stiff portions of the leaf produced. The female specimens have numerous farinaceous tubercles both on the edges of their leaves, and the wrinkles of their furnace. The pulverised leaves have been used as a powder for the hair, and also in dyeing yarn of a red colour.

14. The juniperinus, or common yellow tree-lichen, is common upon the trunks and branches of elms and many other trees. Linnæus says it is very common upon the juniper. The Gothland Swedes dye their yarn of a yellow colour with it, and give it as a specific in the jaundice.

15. The caninus, or ash-coloured ground liverwort, grows upon the ground among moss, at the roots of trees in shady woods, and is frequent also in heaths and stony places. The leaves are large, gradually dilated towards the extremities, and divided into roundish elevated lobes. Their upper side, in dry weather, is ash-coloured; in rainy weather, of a dull fuscous green colour; their underside white and hoary, having many thick downy nerves, from which descend numerous long, white, pencil-like radicles. The peltæ, or shields, grow at the extremities of the elevated lobes, shaped like the human nail; of a roundish oval form, convex above, and concave beneath; of a chocolate colour on the upper side, and the same colour with the leaves on the under. There are two varieties, the one called reddish, and the other many-fingered, ground-liverwort. The former is more common than the other. This species has been rendered famous by the celebrated Dr. Mead, who asserted that it was an

infallible preventative of the dreadful consequences attending the bite of a mad dog.

16. The aphthosus, or green ground liver-wort with black warts, grows upon the ground at the roots of trees in woods, and other stony and mossy places. It differs very little from the foregoing, and according to some is only a variety of it. Linnæus informs us, that the country-people of Upland in Sweden give an infusion of this lichen in milk to children that are troubled with the disorder called the thrush or aphthæ, which induced that ingenious naturalist to bestow upon it the trivial name of aphthosus. The same writer also tells us, that a decoction of it in water purges upwards and downwards, and will destroy worms.

17. The cocciferus or scarlet-tipped cup-lichen, is frequent in moors and heaths. It has in the first state a granulated crust for its ground, which is afterwards turned into small lacinated leaves, green above, and hoary underneath. The plant assumes a very different aspect, according to the age, situation, and other accidents of its growth; but may be in general readily distinguished by its fructifications, which are fungous tubercles of a fine scarlet colour, placed on the rim of the cup, or on the top of the stalk. These tubercles, steeped in an alkaline lixivium, are said to dye a fine durable red colour.

18. The rangiferinus, or rein-deer lichen, is frequent in woods, heaths, and mountainous places. Its general height, when full-grown, is about two inches. The stalk is hollow, and very much branched from bottom to top: the branches are divided and subdivided, and at last terminated by two, three, four, or five very fine, short, nodding horns. The axillæ of the branches are often perforated. The whole plant is of a hoary white or grey colour, covered with white farinaceous particles, light and brittle when dry, soft and elastic when moist. The fructifications are very minute, round, fuscous, or reddish brown tubercles, which grow on the very extremities of the finest branches; but these tubercles are very seldom found. The plant seems to have no foliaceous ground for the base, nor scarcely any visible roots. Linnæus tells us, that in Lapland this moss grows so luxuriant that it is sometimes found a foot high. There are many varieties of this species, of which the principal is the sylvaticus, or brown-tipt rein-deer lichen. The most remarkable difference between them is, that the sylvaticus turns fuscous by age, while the other always continues white.

19. The plicatus, or officinal stringy lichen, grows on the branches of old trees, but is not very common. The stalks are a foot or more in length, cylindrical, rigid, and string-shaped, very irregularly branched, the branches entangled together, of a cinereous or ash-colour, brittle and stringy if doubled short, otherwise tough and pliant, and hang pendant from the trees on which they grow. The shields grow generally at the extremities of the branches, are nearly flat, or slightly concave, thin, ash-coloured above, pale-brown underneath, and radiated with fine rigid fibres. As the plant grows old, the branches become covered with a white-rough, warty crust; but the young ones are destitute of it. It was formerly used in the shops as an astringent to stop hæmorrhages and to cure ruptures; but is out of the modern practice. Linnæus informs us, that the Laplanders apply it to their feet to relieve the excoriation occasioned by much walking.

20. The barbatus, or bearded lichen, grows upon the branches of old trees in thick woods and pine-forests. The stalks or strings are slightly branched and pendulous, from half a foot to two feet in length, little bigger than a taylor's common sewing-thread; cylindrically jointed towards the base; but surrounded every where else with numerous horizontal capillary fibres, either simple or slightly branched. Their colour is a whitish green. This has an astringent quality like the preceding. When steeped in water, it acquires an orange colour; and, according to Dillenius, is used in Pennsylvania for dyeing that colour.

21. The vulpinus, on gold wiry lichen, grows upon the trunks of old trees, but is not very common. It is produced in erect tufts, from half an inch to two inches in height, of a fine yellow or lemon-colour, which readily discovers it. The filaments which compose it are not cylindrical, but a little compressed and uneven in the surface, variously branched, the angles obtuse, and the branches straggling and entangled one with another. Linnæus informs us, that the inhabitants of Smaland in Sweden dye their yarn of a yellow colour with this lichen, and that the Norwegians destroy wolves by stuffing dead carcases with this moss reduced to powder, and mixed with pounded glass, and so exposing them in the winter season to be devoured by those animals.

LICONIA, in botany: a genus of the digynia order, belonging to the pentandria class of plants. There are five petals inlaid in the pit of the nectarium at its base; the capsule is bilocular and seed-bearing.

LICUALA, a genus of the nat. order of palmæ. The flowers are all hermaphrodite: cal. and cor. three-parted, nect. sertiform drupe. There is one species.

LIEUTENANTS, *Lords, of counties,* are officers who, upon any invasion or rebellion, have power to raise the militia, and to give commissions to colonels and other officers, to arm and form them into regiments, troops, and companies. Under the lords-lieutenants, are deputy-lieutenants, who have the same power; these are chosen by the lords-lieutenants, out of the principal gentlemen of each county, and presented to the king for his approbation.

LIFE ANNUITIES, annual payments, to continue during any given life or lives. The present value of a life annuity is the sum which would be sufficient (allowing for the chance of the life failing) to pay the annuity without loss; and supposing money to bear no interest, the value of an annuity of 1*l.* is equal to the expectation of the life. Thus it will be found by the table given under the article EXPECTATION OF LIFE, that the expectation of a life aged forty, is twenty-three years; or, in other words, that a set of lives at this age, will, one with another, enjoy twenty-three years each of existence, some of them enjoying a duration as much longer as others fall short of it. Therefore, supposing money to bear no interest, 23*l.* in hand for each life would be sufficient to pay to any number of such lives 1*l.* per annum, for their whole duration; or, in other words, 23*l.* is, on this supposition, the value of a life aged forty. But if any improvement is made of money by putting it out to interest, the sum just mentioned will be more than the value, because it will be more than sufficient to pay the annuity; and it will be as much more than sufficient as

the improvement or the interest is greater. If, for instance, money may be so improved by being put out to interest, at 5*l.* per cent. as to double itself in fourteen years, the seller of such an annuity, on putting out *half* the purchase money to interest, will at the end of fourteen years find himself in possession of 20*l.* 10*s.* or of 11*l.* 10*s.* more than is sufficient to pay the remainder of the annuities, though he should make no further improvement of the purchase money. At whatever rate of interest the money is improved, there must be a surplus; and if it is fully improved at 5*l.* per cent., it will be found that 11*l.* 16*s.* 8*d.* for each annuity, will be sufficient (instead of 23*l.*) to make all the annual payments; or, if money can be improved at 6*l.* per cent., 10*l.* 14*s.* 1*d.* will be sufficient.

Many persons have fallen into an error with respect to the value of life-annuities, by considering it the same as the value of an annuity certain for a term of years equal to the expectation of the life. The inaccuracy of this mode of computation arises from the difference between the value of a certain number of payments to be made every year regularly till the term is completed, and the value of the same number of payments to be made at greater distances of time from one another, and not to be all made till many years after the expiration of the term equal to the expectation.

The true method of computing the values of life-annuities cannot be more clearly expressed than as it is given in "The Doctrine of Annuities and Assurance on Lives and Survivorships," by William Morgan.—"Was it *certain* that a person of a given age would live to the end of a year, the value of an annuity of 1*l.* on such a life would be the present sum that would increase in a year to the value of a life one year older, together with the value of the single payment of 1*l.* to be made at the end of a year; that is, it would be 1*l.* together with the value of a life aged one year older than the given life, multiplied by the value of 1*l.* payable at the end of a year. Call the value of a life one year older than the given life N, and the value of 1*l.* payable at the end of a year $\frac{1}{r}$; then will the value of an annuity on the given life, on the supposition of a *certainty*, be $\frac{1}{r} + \frac{1}{r} \times N = \frac{1}{r} \times \overline{1+N}$. But the fact is, that it is *uncertain* whether the given life will exist to the end of the year or not: this last value, therefore, must be diminished in the proportion of this uncertainty; that is, it must be multiplied by the probability that the given life will survive one year, or supposing $\frac{b}{a}$ to express this probability, it will be $\frac{b}{ar} \times \overline{1+N}$. In the same manner the values of annuities on the *joint continuance* of lives may be found: Call the value of any two joint lives M, the probability that two lives one year younger will exist a year $\frac{bd}{ac}$, and $\frac{1}{r}$ as above, the value of 1*l.*, payable at the end of the year. Then, by reasoning as before, the value of the joint continuance of two lives one year younger will be expressed by $\frac{bd}{acr} \times \overline{1+M}$."

By these theorems, tables may be calculated of the values of single or joint lives, according to any table of the probabilities of life, and by the use of logarithms, and computing upwards, from the oldest to the youngest life, the labour of forming such tables is not very great; few persons, however, have occasion to undertake it, as the tables published by Dr. Price, Mr. Morgan and Mr. Maseres, show the values of life annuities as accurately as the present knowledge of the decrements and duration of human life will admit; and are sufficient for almost every useful purpose.

TABLE I.

Showing the Value of an Annuity of 1l. on a Single Life at every age, according to the probabilities of the duration of Human Life at Northampton, reckoning interest at 5 per Cent.

Ages.	Value.	Age.	Value.	Age.	Value.
Birth.	8.863	33	12.740	66	7.034
1 year	11.563	34	12.623	67	6.787
2	13.420	35	12.502	68	6.536
3	14.135	36	12.377	69	6.281
4	14.613	37	12.249	70	6.023
5	14.827	38	12.116	71	5.764
6	15.041	39	11.979	72	5.504
7	15.166	40	11.837	73	5.245
8	15.226	41	11.695	74	4.990
9	15.210	42	11.551	75	4.744
10	15.139	43	11.407	76	4.511
11	15.043	44	11.258	77	4.277
12	14.937	45	11.105	78	4.035
13	14.826	46	10.947	79	3.776
14	14.710	47	10.784	80	3.515
15	14.588	48	10.616	81	3.263
16	14.460	49	10.443	82	3.020
17	14.334	50	10.269	83	2.797
18	14.217	51	10.097	84	2.627
19	14.108	52	9.925	85	2.471
20	14.007	53	9.748	86	2.328
21	13.917	54	9.567	87	2.193
22	13.833	55	9.382	88	2.080
23	13.746	56	9.193	89	1.924
24	13.658	57	8.999	90	1.723
25	13.567	58	8.801	91	1.447
26	13.473	59	8.599	92	1.153
27	18.377	60	8.392	93	0.816
28	13.278	61	8.181	94	0.524
29	13.177	62	7.966	95	0.238
30	13.072	63	7.742	96	0.000
31	12.965	64	7.514		
32	12.854	65	7.276		

These values suppose the payments to be made *yearly*, and to begin at the end of the first year; if the payments are to be made *half-yearly*, the value in the table will be increased about one-fifth of a year's purchase.

In order to find the present value of an annuity during any given life, it is only necessary to multiply the value in the table corresponding with the age, by the given annuity.

Example. What should a person aged 45, give, to purchase an annuity of 50*l.* during his life?

The value in the table against 45 years is 11.105, which multiplied by 50 gives the answer 555*l.* 5*s.*

TABLE II.

Showing the Value of an Annuity during the joint continuance of Two Lives, according to the probabilities of Life at Northampton; reckoning interest at 5 per Cent.

Ages.	Value.	Ages	Value.	Ages.	Value.
5-5	11.984	20-25	10.959	40-45	8.643
5-10	12.315	20-30	10.707	40-50	8.177
5-15	11.954	20-35	10 363	40-55	7.651
5-20	11.561	20-40	9.937	40-60	7.015
5-25	11.281	20-45	9.448	40-65	6.240
5-30	10.959	20-50	8.861	40-70	5.298
5-35	10.572	20-55	8.216	40-75	4.272
5-40	10.102	20-60	7.463	40-80	3.236
5-45	9.571	20-65	6.576	45-45	8.312
5-50	8.941	20-70	5.532	45-50	7.891
5-55	8.256	20-75	4.424	45-55	7.411
5-60	7.466	20-80	3.325	45-60	6.822
5-65	6.546	25-25	10.764	45-65	6.094
5-70	5.472	25-30	10.499	45-70	5.195
5-75	4.362	25-35	10.178	45-75	4.206
5-80	3.238	25-40	9.771	45-80	3.197
10-10	12.665	25-45	9.304	50-50	7.522
10-15	12.302	25-50	8.739	50-55	7.098
10-20	11.906	25-55	8.116	50-60	6.568
10-25	11.627	25-60	7.388	50-65	5.897
10-30	11·304	25-65	6.515	50-70	5.054
10-35	10.916	25-70	5.489	50-75	4.112
10-40	10.442	25-75	4.396	50-80	3.140
10-45	9.900	25-80	3.308	55-55	6.735
10-50	9.260	30-30	10.255	55-60	6.272
10-55	8.560	30-35	9.954	55-65	5.671
10-60	7.750	30-40	9.576	55-70	4.893
10-65	6.803	30-45	9.135	55-75	4.006
10-70	5.700	30-50	8.596	55-80	3.076
10-75	4.522	30-55	7.999	60-60	5.388
10-80	3.395	30-60	7.292	60-65	5.372
15-15	11.960	30-65	6.447	60-70	4.680
15-20	11.585	30-70	5.442	60-75	3.866
15-25	11.324	30-75	4.365	60-80	2.992
15-30	11.021	30-80	3.290	65-65	4.960
15-35	10.655	35-35	9.680	65-70	4.378
15-40	10.205	35-40	9.331	65-75	3.665
15-45	9.690	35-45	8.921	65-80	2.873
15-50	9.076	35-50	8.415	70-70	3.930
15-55	8.403	35-55	7.849	70-75	3.347
15-60	7.622	35-60	7.174	70-80	2.675
15-65	6.705	35-65	6.360	75-75	2.917
15-70	5.631	35-70	5.382	75-80	2.381
15-75	4.495	35-75	4.327	80-80	2.018
15-80	3.372	35-80	3.268	85-85	1.256
20-20	11.232	40-40	9.016	90-90	0.909

It is unnecessary to insert a Table of the values of the longest of two lives, as it may be easily found from the values given in the above tables by the following general rules:

" From the sum of the values of the single lives subtract the value of an annuity on the joint lives, and the remainder will give the value of an annuity on the continuance of the longest of two such lives."

Example. What is the value of an annuity on the longest of two lives whose ages are thirty and forty?

By Table I. the value of a single life of 30 is 13.072, and by the same Table the value of a single life of 40 is 11.837. Their sum therefore is 24.909, from which 9.576 (the value of the joint lives of 30 and 40 by Table II.) being subtracted, gives 15.333 for the number of years purchase required.

The value of an annuity on three joint lives may be found from the preceding tables, by the following rule:

" Let A be the youngest, and C the oldest of the three proposed lives. Take the value of the two joint lives B and C, and find the age of a single life D of the same value. Then find the value of the joint lives A and D, which will be the answer."

Example. Let the three given lives be 20, 30, and 40. The value of the two oldest joint lives B and C will (by Table II.) be 9.576, answering in Table I. to a single life D of 54 years; and the value of the joint lives A and D, or the ages in the Table which come nearest to them, gives 8.216 for the value sought.

The value of three joint lives being known, the value of the longest of any three lives may be computed by the following rule:

" From the sum of the values of all the single lives, subtract the sum of the values of all the joint lives combined two and two. Then to the remainder add the value of the three joint lives; and this last sum will be the value of the longest of the three lives."

Example. The sum of the values of three single lives whose ages are 20, 30, and 40, is (by Table I.) 38.916. The value of two joint lives, whose ages are 20 and 30, is (by Table II.) 10.707; of two joint lives whose ages are 20 and 40, is 9.937, and two joint lives whose ages are 30 and 40 is 9.576; the sum of these three values is 30.220. This sum subtracted from 38.916, leaves 8.696, which remainder added to 8.216 (the value of the three joint lives in the last example), gives 16.912, the value of the longest of the three lives. The answers in this and the preceding example are not quite exact, in consequence of the table of joint lives being confined to the combinations of every fifth year of age; those who have occasion to make such computations, will find more extensive tables of the values of joint lives in Dr. Price's excellent Treatise on Reversionary Payments; but a general table of the values of two joint lives for every possible difference of age, at different rates of interest, has long been very desirable.

The solutions of the following Problems, in addition to the rules already given, will comprehend all the cases which most commonly occur relating to the values of annuities on lives or survivorship.

Prob. I. To determine the value of an annuity on a given life for any number of years.

Solution. Find the value of a life as many years older than the given life as are equal to the term for which the annuity is proposed. Multiply this value by 1*l.*, payable at the end of this term, and also by the probability that the life will continue so long. Subtract the product from the present value of the given life, and the remainder multiplied by the annuity will be the answer.

Example. Let the annuity be 20*l.* the age of the given life 35 years, and the term proposed 14 years. The value

of a life aged 49 years (or 14 years older than the given life), appears by Table I. to be 10,443. The value of 1*l.* payable at the end of 14 years (see COMPOUND INTEREST), is .505068, and the probability that the life will exist so long, (See EXPECTATION of LIFE) is $\frac{2936}{4010}$. These three values multiplied into each other are equal to 3.861, which being subtracted from 12.502 (the present value of the given life by Table I.), we have 8.641, and this remainder multiplied by 20, gives 162*l.* 16*s.* 4*d.* for the value required.

In a similar manner the value of an annuity for any given term, upon two joint lives, may be determined.

PROB. II. To find the value of an annuity certain for a given term after the extinction of any given life or lives.

Solution. Subtract the value of the life or lives from the perpetuity, and reserve the remainder. Then say, as the perpetuity, is to the present value of the annuity certain, so is the said reserved remainder, to a fourth proportional, which will be the number of years purchase required.

Example. A and his heirs are entitled to an annuity certain for 14 years, to commence at the death of B, aged 35. What is the present value of A's interest in this annuity?

By table I. the value of the life of B is 12,502, which subtracted from 20, the perpetuity, leaves 7.498 for the remainder to be reserved. Then, as 20, is to 9.898 (the value of an annuity certain for 14 years), so is 7.498 (the reserved remainder), to 3.7107, the number of years purchase required.

PROB. III. To find the value of an annuity for a term certain, and also for what may happen to remain of a given life or lives after the expiration of this term.

Solution. Find the value of a life or lives as many years older than the given life or lives as are equal to the term for which the annuity certain is proposed. Multiply this value by 1*l.* payable at the end of the given term, and also by the probability that the given life or lives will continue so long. Add the product to the value of the annuity certain for the given term, and the sum will be the answer.

Example. Let the value be required of an annuity certain for 14 years, and also for the remainder of a life now aged 35 after the expiration of this term. By Table I. the value of a life aged 49 (or 14 years older than the given life) is 10.443. The value of 1*l.* payable at the end of 14 years, is .505068, and the probability that the life will exist so long is $\frac{2936}{4010}$. These three numbers multiplied into each other, produce 3.861, which being added to 9.898, the value of an annuity certain for 14 years (see ANNUITIES), becomes equal to 13.759, the number of years purchase required.

PROB. IV. To determine what annuity any given sum will purchase during the joint lives of two persons of given ages, and also during the life of the survivor, on condition that the annuity shall be reduced one-half at the extinction of the joint lives.

Solution. Let twice the given sum be divided by the sum of the two single lives, and the quotient will give the annuity to be paid during the joint lives: one-half of which is therefore the annuity to be paid during the remainder of the surviving life.

Example. A aged 27, and B aged 35, are desirous of sinking 1000*l.* in order to receive an annuity during their joint lives, and also another annuity of half the value during the remainder of the surviving life. It is required to determine what annuities should be granted them under those circumstances. By Table I. the value of a life of 27 is 13.377, and the value of a life of 35 is 12.502. 2000*l.* (or twice the given sum) being divided by 25.879 (the sum of the values of the two lives), gives 77.282*l.* for the annuity to be granted during the joint continuance of the lives; and its half, or 38.641*l.* is the annuity to be paid during the life of the survivor.

PROB. V. B, who is of a given age, will, if he lives till the decease of A, whose age is also given, become possessed of a perpetual annuity, or of an estate of a given yearly value; to find the worth of his expectation in present money.

Solution. Find the value of an annuity on two equal joint lives whose common age is equal to the age of the oldest of the two proposed lives, which value subtract from the perpetuity, and take half the remainder: then say, as the expectation of duration of the younger of the two lives, is to that of the older, so is the said half remainder, to a fourth proportional: which will be the number of years purchase required when the life of B in expectation is the older of the two: but if B be the younger, then add the value so found to that of the joint lives A and B, and let the sum be subtracted from the perpetuity, and you will also have the answer in this case.

Example. Suppose the age of B to be 30, and that of A 20 years, and the value of the estate 50*l.* per annum. Then the value of two equal joint lives, aged 30, is, by Table II. 10.255, and the perpetuity being 20, the difference will be 9.745, the half of which is 4.872. Therefore as 33.43, the expectation of A, is to 28.27, the expectation of B, so is 4.872, to 4.119, which being multiplied by 50, the given annuity, we have 205.95*l.* for the required value of B's expectation.

If the age of B had been 20, and that of A 30 years, then to 4.119, the value just found, add the value of the joint lives, which, by Table II. is 10.707, and the sum is 14.826, which subtracted from 20, the perpetuity, and the remainder multiplied by 50, gives 258.7*l.* for the required value in this case.

LIFE ESTATES are of two kinds, such as are created by the act of the parties, or such as are created by the operation of the law, as estates by curtesy or dower. 2 Black. 120.

Estates for life, created by deed or grant, are, where a lease is made of lands or tenements to a man, to hold for the term of his own life, or for that of another person, or for more lives than one; in any of which cases, he is called tenant for life: only when he holds the estate by the life of another, he is usually termed tenant pur auter vie, for another's life.

Estates for life may be created not only by the express terms before-mentioned, but also by a general grant, without defining or limiting any specific estate. 2 Black. 121.

If such persons, for whose life any estate shall be granted, shall absent themselves seven years, and no proof made of the lives of such persons, in any action commenced for the recovery of such tenements by the

lessors or reversioners, the persons upon whose lives such estate depended, shall be accounted as dead; and the judges shall direct the jury to give their verdict as if the person absenting himself was dead. 19 Car. II. c. 6.

LIGAMENT. See ANATOMY.

LIGATURE. See SURGERY.

LIGHT. See OPTICS.

LIGHTS: stopping lights of any house is a nauisance, for which an action will lie, if the house is an ancient house, and the lights ancient lights: but stopping a prospect is not, being only matter of delight, not of necessity; and a person may have either an assize of nuisance against the persons erecting any such nuisance, or he may stand on his own ground and abate it. 2 Salk. 247.

LIGHTFOOTIA, a genus of the class and order polygamia dioecia. The cal. is four-leaved; cor. none; fem. and her. stigma sessile; berry umbilicated. There are three species, shrubs of the E. Indies.

LIGHTNING. See ELECTRICITY.

LIGUSTICUM, lovage; a genus of the digynia order, in the pentandria class of plants; and in the natural method ranking under the 45th order, umbellatæ. The fruit is oblong, and quinquesulcated on each side; the florets are equal; the petals involuted or rolled inwards, and entire. There are eight species, of which the most remarkable are, the levisticum, or common, and the Scoticum, or Scots, lovage. The first is a native of the Appenine mountains in Italy. The second is a native of Scotland, and grows near the sea in various parts of the country.

The root of the first species agrees nearly in quality with that of angelica: the principal difference is, that the lovage root has a stronger smell, and a somewhat less pungent taste, accompanied with a more durable sweetness, the seeds being rather warmer than the root; but although certainly capable of being applied to useful purposes, this root is not regarded in the present practice. The leaves of the second are sometimes eaten raw as a salad, or boiled as greens, by the inhabitants of the Hebrides. They give an infusion of the leaves in whey to calves. to purge them.

LIGUSTRUM, *privet*, a genus of the monogynia order, in the diandria class of plants; and in the natural method ranking under the 44th order, sepiariæ. The corolla is quadrifid; the berry tetraspermous. There are three species; of the common there are two varieties, the deciduous and the evergreen. They are hardy plants, rising from ten to fifteen feet high. They are easily propagated by seed, layers, suckers, or cuttings. They are used for making hedges. The purple colour upon cards is prepared from the berries. With the addition of alum, these berries are said to dye wool and silk of a good and durable green; for which purpose they must be gathered as soon as they are ripe. The leaves are bitter and slightly astringent. Oxen, goats, and sheep, eat the plant; horses refuse it.

LIKE, in geometry, &c. denotes the same with similar. See SIMILAR.

LILAC, in botany, a genus of trees, otherwise called syringa. See SYRINGA.

LILALITE. This stone appears to have been first observed by the abbe Poda, and to have been then described by De Born. Hitherto it has only been found in Moravia in Germany, and Sudermania in Sweden. There it is mixed with granite in large amorphous masses. It is composed of thin plates, easily separated, and not unlike those of mica. Not easily pulverised. Specific gravity 2.8549. Colour of the mass, violet-blue; of the thin plates, silvery white. Powder white, with a tint of red. Before the blowpipe, it froths, and melts easily into a white semi-transparent enamel, full of bubbles. Dissolves in borax with effervescence, and communicates no colour to it. Effervesces slightly with soda, and melts into a mass spotted with red. With microcosmic salts it gives a pearl-coloured globule.

This stone was first called lilalite from its colour, that of the lily. Klaproth, who discovered its component parts, gave it the name of lepidolite.

It is composed of

53	silica
20	alumina
18	potass
5	fluat of lime
3	oxide of manganese
1	oxide of iron
100.	

LILIUM, the *lily;* a genus of the monogynia order, in the hexandria class of plants; and in the natural method ranking under the 10th order, coronariæ. The corolla is hexapetalous, and campanulated, with a longitudinal nectariferous line or furrow; the capsules connected by small cancellated hairs. There are eleven species; all of them bulbous-rooted, herbaceous, flowery perennials, rising with erect annual stalks three or four feet high, garnished with long narrow leaves, and terminated by fine clusters of large, bell-shaped, hexapetalous flowers of great beauty, of white, red, scarlet, orange, purple, and yellow colours.

All the species are propagated by sowing the seeds; and if care is taken to preserve these seeds from good flowers, very beautiful varieties are often produced.

The roots of the white lily are emollient, maturating, and suppurative, and are used externally in cataplasms for these purposes with success. The common form of applying them is, boiled and bruised. Gerard recommends them internally against dropsies.

The Kamtschatence, or Kamtschatka lily, called there saranne, makes a principal part of the food of Kamtschatkans. Its roots are gathered by the women in August, dried in the sun, and laid up for use: they are the best bread of the country; and after being baked are reduced to powder, and serve instead of flour in soups and several dishes. They are sometimes washed, and eaten as potatoes; are extremely nourishing, and have a pleasant bitter taste. Our navigators boiled and ate them with their meat. The natives often parboil, and beat it up with several sorts of berries, so as to form of it a very agreeable confection. Providentially it is an universal plant there, and all the grounds bloom with its flower during the season. Another happiness remarked there is, that while fish are scarce, the saranne is plentiful; and when there is a dearth of this, the rivers pour in their provisions with redoubled profusion. It is not to the labours of the females alone that the Kamtschatkans

are indebted for these roots. A species of mouse saves them a great deal of trouble. The saranne forms part of the winter provisions of that little animal: they not only gather them in the proper season, and lay them up in their magazines, but at times have the instinct of bringing them out in sunny weather to dry them, lest they should decay. The natives search for their hoards; but with prudent tenderness leave part for the owners, being unwilling to suffer such useful caterers to perish.

LIMAX, the *slug*, or naked snail; a genus of insects belonging to the order of vermes mollusca. The body is oblong, fitted for crawling, with a kind of muscular coat on the upper part, and the belly is plain. They have four tentacula, or horns, situated above the mouth, which they extend or retract at pleasure. This reptile is always destitute of shell; but besides that its skin is more clammy, and of a greater consistency, than that of the snail, the black naked slug has a furrowed cloak, almost as thick and as hard as leather, under which it withdraws its head as within a shell. The head is distinguished from the breast by a black line. It is in its head and back that the snail-stone is found; which is a small pearled and sandy stone, of the nature of limestones: according to a popular opinion, it cures the tertian ague, if fastened to the patient's arm. These slugs move on slowly, leaving every where clammy and shining marks of their passage. They deposit their eggs in the earth. There are eight species, distinguished entirely by their colour; as the black slug, the white slug, the reddish slug, the ash-coloured slug, &c. The black slug is hermaphrodite. A black slug, powdered over with snuff, salt, or sugar, falls into convulsions, casts forth all its foam, and dies.

LIME, one of those earthy substances, which exist in every part of the known world. It is found purest in limestone, marble, and chalk. None of these substances are lime, but are capable of becoming so by burning in a white heat.

Lime may be also obtained perfectly pure by burning those crystallized limestones called calcareous spars, which are perfectly white and transparent, and also by burning some pure white marbles. It may be procured also in a state of purity by dissolving oyster-shells in muriatic acid, filtring the solution, mixing it with ammonia as long as a white powder continues to fall, and filtring again. The liquid is now to be mixed with a solution of carbonat of soda: the powder which falls being washed and dried, and heated violently in a platinum crucible, is pure lime.

Pure lime is of a white colour, moderately hard, but easily reduced to a powder. It has a hot burning taste, and in some measure corrodes and destroys the texture of those animal bodies to which it is applied. Its specific gravity is 2.3. It tinges vegetable blues green, and at last converts them to yellow.

If water be poured on newly burnt lime, it swells and falls to pieces, and is soon reduced to a very fine powder. In the mean time so much heat is produced, that part of the water flies off in vapour. If the quantity of lime slacked (as this process is termed) be great, the heat produced is sufficient to set fire to combustibles. In this manner, vessels loaded with lime have sometimes been burnt. When great quantities of lime are slacked in a dark place, not only heat but light also is emitted, as Mr. Pelletier has observed. When slacked lime is weighed, it is found to be heavier than it was before. This additional weight is owing to the combination of part of the water with the lime; which water may be separated again by the application of a red heat; and by this process the lime becomes just what it was before being slacked. Hence the reason of the heat evolved during the slacking of lime. Part of the water combines with the lime, and thus becomes solid; of course it parts with its caloric of fluidity, and probably also with a considerable quantity of caloric, which exists in water even when in the state of ice: for when two parts of lime and one part of ice (each at 32°) are mixed, they combine rapidly, and their temperature is elevated to 212°. The elevation of temperature during the slacking of barytes and strontian is owing to the same cause.

The smell perceived during the slacking of lime is owing to a part of that earth being elevated along with the vapour of the water; as evidently appears from this circumstance, that vegetable blues exposed to this vapour are converted to green.

Limestone and chalk, though they are capable of being converted into lime by burning, posesses hardly any of the properties of that active substance. They are tasteless, scarcely soluble in water, and do not perceptibly act on animal bodies. Now, to what are the new properties of lime owing? What alteration does it undergo in the fire?

It had been long known, that limestone loses a good deal of weight by being burned or calcined. It was natural to suppose, therefore, that something is separated from it during calcination. Dr. Black, of Edinburgh, published in 1756, those celebrated experiments on this subject, which form so brilliant an era in the history of chemistry. He first ascertained, that the quantity of water separated from limestone during its calcination is not nearly equal to the weight which it lost. He concluded in consequence, that it must have lost something else than mere water. What this could be, he was at first at a loss to conceive; but recollecting that Dr. Hales had proved, that limestone, during its solution in acids, emits a great quantity of air, he conjectured that this might probably be what it lost during calcination. He calcined it accordingly, and applied a pneumatic apparatus to receive the product. He found his conjecture verified; and that the air and water which separated from the lime were together precisely equal to the loss of weight which it had sustained. Lime, therefore, owes its new properties to the loss of air; and limestone differs from lime merely in being combined with a certain quantity of air: for he found that, by restoring again the same quantity of air to lime, it was converted into limestone. This air, because it existed in lime in a fixed state, he called fixed air. It was afterwards examined by Dr. Priestley and other philosophers; found to possess peculiar properties, and to be that species of gas now known by the name of carbonic acid gas. Lime then is a simple substance, and limestone is composed of carbonic acid and lime. Heat separates the carbonic acid, and leaves the lime in a state of purity. See Air.

When lime is exposed to the open air, it gradually attracts moisture, and falls to powder; after which it soon

becomes saturated with carbonic acid, and is again converted into carbonat of lime or unburnt limestone.

Water, at the common temperature of the atmosphere, dissolves about 0.002 parts of its weight of lime. This solution is called lime-water. It is limpid, has an acrid taste, and changes vegetable blue colours to green. One ounce tr y of lime-water contains about one grain of lime. It is usually formed by throwing a quantity of lime in powder into pure water, allowing it to remain for some time in a close vessel, and then decanting the transparent solution from the undissolved lime. When lime-water is exposed to the air, a stony crust soon forms on its surface, composed of carbonat of lime; when this crust is broken it falls to the bottom and another succeeds it; and in this manner the whole of the lime is soon precipitated, by absorbing carbonic acid from the air.

Lime is not acted on by light, neither does it combine with oxygen. Sulphur and phosphorus are the only simple combustibles with which it unites.

Sulphuret of lime may be formed by mixing its two component parts, reduced to a powder, and heating them in a crucible. They undergo a commencement of fusion, and form an acrid taste. When it is exposed to the air, or moistened with water, its colour becoming greenish yellow, sulphureted hydrogen is formed, and the sulphuret is converted into a hydrogenated sulphuret, which exhales a very fetid odour of sulphureted hydrogen gas. This hydrogenated sulphuret may be formed also by boiling a mixture of lime and sulphur in about ten times its weight of water, or by sprinkling quicklime with sulphur and then moistening it: the heat occasioned by the slacking of the lime is sufficient to form the combination. When this hydrogenated sulphuret is exposed to the air, it imbibes oxygen; which combines at first with the hydrogen, and afterwards with the sulphur, and converts the compound into sulphat of lime.

Phosphuret of lime may be formed by the following process: put into the bottom of a glass tube, close at one end, one part of phosphorus; and, holding the tube horizontally, introduce five parts of lime in small lumps, so that they shall be about two inches above the phosphorus. Then place the tube horizontally among burning coals, so that the part of it which contains the lime may be made red-hot, while the bottom of the tube containing the phosphorus remains cold. When the lime becomes red-hot, raise the tube, and draw it along the coals till that part of it which contains the phosphorus is exposed to a red heat. The phosphorus is immediately volatilized, and passing through the hot lime combines with it. During the combination the mass becomes of a glowing red heat, and a quantity of phosphureted hydrogen gas is emitted, which takes fire when it comes into the air.

Lime does not combine with azote; but it unites readily with muriatic acid, and forms muriate of lime. It facilitates the oxidizement of several of the metals, and it combines with several of the metallic oxides, and forms salts which have not hitherto been examined, if we except the compounds which it forms with the oxides of mercury and lead, which have been described by Berthollet.

The red oxide of mercury, boiled with lime-water, is partly dissolved, and the solution yields by evaporation small transparent yellow crystals. This compound has been called by some mercuriat of lime.

Lime-water also dissolves the red oxide of lead, and (still better) litharge. This solution, evaporated in a retort, gives very small transparent crystals, forming prismatic colours, and not more soluble in water than lime. It is decomposed by all the alkaline sulphats, and by sulphureted hydrogen gas. The sulphuric and muriatic acids precipitate the lead. This compound blackens wool, the nails, the hair, and white of eggs; but it does not affect the colour of silk, the skin, the yolk of egg, nor animal oil. It is the lead which is precipitated on these coloured substances in the state of oxide; for all acids can dissolve it. The simple mixture of lime and oxide of lead blackens these substances; a proof that the salt is easily formed.

Lime does not combine with alkalies. The affinities of lime are arranged by Bergman in the following order:

Oxalic acid	Arsenic
Sulphuric	Lactic
Tartaric	Citric
Succinic	Benzoic
Phosphoric	Sulphurous
Saclactic	Acetic
Nitric	Boracic
Muriatic	Carbonic
Suberic	Prussic
Fluoric	

One of the most important uses of lime is, in the formation of mortar as a cement in building. Mortar is composed of quicklime and sand reduced to a paste with water. When dry it becomes as hard as stone, and as durable; and adhering very strongly to the surfaces of the stones which it is employed to cement, the whole wall becomes in fact nothing else than one single stone. But this effect is produced very imperfectly unless the mortar is very well prepared.

The lime ought to be pure, completely free from carbonic acid, and in the state of a very fine powder: the sand should be free from clay, and partly in the state of fine sand, partly in that of gravel: the water should be pure; and if previously saturated with lime, so much the better. The best proportions, according to the experiments of Dr. Higgins, are three parts of fine sand, four parts of coarse sand, one part of quicklime recently slacked, and as little water as possible.

The stony consistence which mortar acquires, is owing partly to the absorption of carbonic acid, but principally to the combination of part of the water with the lime. This last circumstance is the reason that if to common mortar one-fourth part of lime, reduced to powder without being slacked, is added, the mortar, when dry, acquires much greater solidity than it otherwise would do. This was first proposed by Loriot; and a number of experiments were afterwards made by Morveau. The proportions which this philosopher found to answer best are the following:

Fine sand - - -	0.3
Cement of well-baked bricks	0.3
Slacked lime - - -	0.2
Unslacked lime - -	0.2
	1.0

The same advantages may be attained by using as little water as possible in slacking the lime.

Higgins found that the addition of burnt bones improved mortar by giving it tenacity, and rendering it less apt to crack in drying; but they ought never to exceed one-fourth of the lime employed.

When a little manganese is added to mortar, it acquires the important property of hardening under water; so that it may be employed in constructing those edifices which are constantly exposed to the action of water. Limestone is often combined with manganese: in that case it becomes brown by calcination.

LIMESTONE. See SALTS, *calcareous*.

LIMESTONE, *primitive* and *secondary*. See ROCKS.

LIMEUM, a genus of the class and order heptandria digynia. The cal. is five-leaved; pet. five; caps globular, two-celled. There are three species, herbaceous plants of the Cape.

LIMIT, in a restrained sense, is used by mathematicians for a determinate quantity to which a variable one continually approaches; in which sense the circle may be said to be the limit of its circumscribed and inscribed polygons. In algebra, the term limits is applied to two quantities, one of which is greater, and the other less, than another quantity; and in this sense it is used in speaking of the limits of equations, whereby their solution is much facilitated.

Let any equation, as $x^3 - px^2 \times qx - r = 0$ be proposed; and transform it into the following equation:

$$\left.\begin{array}{l} y^3 + 3ey^2 + 3ey^2 + e^3 \\ py - py^2 - 2pey - pe^2 \\ \quad + qy + qe \\ \quad\quad - r \end{array}\right\} = 0,$$

where the values of y are less than the respective values of x, by the difference e. If you suppose e to be taken such as to make all the co-efficients of the equation of y positive, viz. $e^3 - pe^2 + qe - r$, $3e^2 - 2pe + q$, $3e - p$; then there being no variation of the signs in the equation, all the values of y must be negative; and consequently the quantity e, by which the values of x are diminished, must be greater than the greatest positive value of x: and, consequently, must be the limit of the roots of the equation $x^3 - px^2 + qx - r = 0$.

It is sufficient, therefore, in order to find the limit, to inquire what quantity substituted for x, in each of these expressions $x^3 - px^2 + qx - r$, $3x^2 - 2px + q$, $3x - p$, will give them all positive; for the quantity will be the limit required.

Having found the limit that surpasses the greatest positive root, call it m. And if you assume $y = m - x$, and for x substitute $m - y$, the equation that will arise will have all its roots positive; because m is supposed to surpass all the values of x, and consequently $m - x$ $(= y)$ must always be affirmative. And by this means, any equation may be changed into one that shall have all its roots affirmative.

Or, if $-n$ represent the limit of the negative roots, then by assuming $y - x + n$, the proposed equation shall be transformed into one that shall have all its roots affirmative; for, $+ n$ being greater than any negative value of x, it follows that $y = x - n$ must be always positive.

What is here said of the above cubic equation, may be easily applied to others; and of all such equations, two limits are easily discovered, viz. o, which is less than the least; and e, found as above, which surpasses the greatest root of the equation. But besides these, other limits still nearer the roots may be found: for the method of doing which, the reader may consult Maclaurin's Algebra.

LIMITATION, a certain time prescribed by statute, within which an action must be brought. The time of limitation is twofold; first in writs, by divers acts of parliament; secondly, to make a title to any inheritance, and that is by the common law.

Limitation on penal statutes.—All actions, suits, bills, indictments, or informations, which shall be brought for any forfeiture upon any statute penal, made or to be made, whereby the forfeiture is or shall be limited to the queen, her heirs or successors only, shall be brought within two years after the offence committed, and not after two years; and all actions, suits, bills, or informations, which shall be brought for any forfeiture upon any penal statute, made or to be made, except the statutes of tillage, the benefit and suit whereof is or shall be by the said statute limited to the queen, her heirs or successors, and to any other that shall prosecute in that behalf, shall be brought by any person that may lawfully sue for the same, within one year next after the offence committed; and in default of such pursuit, then the same shall be brought for the queen's majesty, her heirs or successors, any time within the two years, after that year is ended; and it is provided, that where a shorter time is limited by any penal statute, the prosecution must be within that time. 31 Eliz. c. 5.

Limitation in regard to personal actions of assault and battery, and actions arising upon contract and trespass.

All actions of trespass, of assault, battery, wounding, imprisonment, or any of them, shall be commenced and sued within four years next after the cause of such actions or suits, and not after. 21 Jac. I. c. 16.

Actions of account, &c.—All actions of trespass quare clausum fregit, all actions of trespass, detinue, trover, and replevin, all actions of account, and upon the case (other than such accounts as concern the trade of merchandize, between merchant and merchant), all actions of debt grounded upon any lending, or contract without specialty, (that is, not being by deed or under seal) all actions of debt for arrearages of rent, and all actions of assault, menace, battery, wounding, and imprisonment, shall be commenced within the time and limitation as followeth, and not after; that is to say, the said actions upon the case (other than for slander), and the said actions for trespass, debt, detinue, and replevin, and the said acts for trespass quare clausum fregit, within six years, after the cause of such action. 21 Jac. c. 16.

Exception in relation to infants.—It has been holden, that if an infant during his infancy, by his guardian bring an action, the defendant cannot plead the statute of limitation, although the cause of action accrued six years before; and the words of the statute are, that after his coming of age, &c.

Exception in relation to merchants' accounts.—As to this exception, it has been matter of much controversy,

whether it extends to all actions and accounts relating to merchants and merchandize, or to actions of account open and current only. But it is now settled, that accounts open and current only are within the statute; and that therefore, if an account be stated and settled between merchant and merchant, and a sum certain agreed to be due to one of them, if in such case, he to whom the money is due, do not bring his action within the limited time, he is barred by the statute. 2 Mod. 312.

Exception in relation to persons beyond sea.—It seems to have been agreed that the exception as to persons being beyond sea, extends only where the creditors or plaintiffs are so absent, and not to debtors or defendants, because the first only are mentioned in the statute; and this construction has the rather prevailed, because it was reputed the creditor's folly, that he did not file an original, and outlaw the debtor, which would have prevented the bar of the statutes.

Executor or administrator.—If A receives money belonging to a person who afterwards died intestate, and to whom B takes out administration, and brings an action against A, to which he pleads the statute of limitations, and the plaintiff replies, and shows that administration was committed to him such a year, which was within six years; though six years are expired since the receipt of the money, yet not being so since the administration committed, the action is not barred by the statute. 1 Salk. 421.

Where a debt barred by the statute shall be revived.—Any acknowledgment of the existence of the debt, however slight, will take it out of the statute, and the limitation will then run from that time: and where an expression is ambiguous, it shall be left to the consideration of the jury, whether it amounts or not to such acknowledgment. 2 Durnf. & East, 760.

It is clearly agreed, that if after the six years, the debtor acknowledges the debt, and promise payment, that this revives it, and brings it out of the statute: as if a debtor by promissory note, or simple contract, promises within six years of the action brought, that he will pay the debt; though this was barred by the statute, yet it is revived by the promise; for as the note itself was at first but an evidence of the debt, so that being barred the acknowledgment and promise is a new evidence of the debt, and being proved, will maintain an assumpsit for recovery of it. 1 Salk. 28.

Limits of a planet, its greatest excursion from the ecliptic, or which is the same thing, the points of its greatest latitude.

LIMITED problem, a problem that admits but of one solution, as to make a circle pass through three given points, not lying in the same right line.

LIMOSELLA, a genus of the didynamia angiospermia class of plants: the flower consists of one erect petal, divided into five segments; fruit is an unilocular capsule, with a great many seeds. Two species, annuals of the Cape.

LIMODORUM, a genus of the gynandria diandria class of plants, the flower of which consists of five oblong petals, and the nectarium hollow, and formed of a single leaf: the fruit is a columnar unilocular capsule, containing a great number of very small seeds. There are thirteen species, bulbs of America, &c.

LIMONIA, a genus of the decandria monogynia class and order. The cal. is five-parted; pet. five-berry, three-celled. Seeds solitary. There are seven species, trees of the East Indies, &c.

LINCONIA, a genus of the class and order pentandria digynia. The pet. are five; caps. two-celled. There is one species, a shrub of the Cape.

LINDERA, a genus of the class and order hexandria monogynia. The cor. is six-petalled; caps. two-celled. There is one species, a shrub of Japan.

LINDERNIA, a genus of the class and order didynamia angiospermia. The cal. is five-parted; caps. one-celled. There are three species, annuals of America.

LINE, in geometry, a quantity extended in length only, without any breadth or thickness. It is formed by the flux or motion of a point: see Fluxion, and Geometry. Right lines are all of the same species, but curves are of an infinite number of different species. We may conceive as many as there may be different ratios between their ordinates and abscisses.

Curve lines are usually divided into geometrical and mechanical; the former are those which may be found exactly in all their points; the latter are those, some or all of whose points are not to be found precisely, but only tentatively, or nearly.

Curve lines are also divided into the first order, second order, third order, &c. See Curve.

Lines considered as to their positions, are either parallel, perpendicular, or oblique, the construction and properties whereof see under Parallel, &c.

Euclid's second book treats mostly of lines, and of the effects of their being divided and again multiplied into one another.

Lines, in perspective, are, 1. Geometrical line, which is a right line drawn in any manner on the geometrical plane. 2. Terrestrial line, or fundamental line, is a right line wherein the geometrical plane, and that of the picture or draught, intersect one another. See Perspective.

Lines. See Dialling.

Line of direction on the earth's axis, in the Pythagorean system of astronomy, the line connecting the two poles of the ecliptic and of the equator, when they are projected on the plane of the former.

Line of direction. See Mechanics.

Line of gravitation of any heavy body, a line drawn through its centre of gravity, and according to which it tends downwards.

Line of the swiftest descent of a heavy body, is the cycloid. See Cycloid.

Lines on the plain scale, are the line of chords, line of sines, line of tangents, line of secants, line of semitangents, line of leagues; the construction and application of which see under the words Scale, Sailing, Instruments, &c.

Lines on Gunter's scale. See Gunter's Scale.

Lines of the sector. See Instruments.

Lines, in fortification, are those of approach, capital defence, circumvallation, contravallation of the base, &c.

To Line a work, signifies to strengthen a rampart with a firm wall; or to encompass a parapet or moat with good turf, &c.

Line, in the art of war, is understood of the disposition of an army, ranged in order of battle, with the front extended as far as may be, that it may not be flanked.

Line of battle, is also understood of the disposition of a fleet on the day of engagement.

Ship of the Line, a vessel large enough to be drawn up in the line, and to have a place in a sea-fight.

Line, also denotes a French measure, containing the twelfth part of an inch, or the hundred and forty-fourth part of a foot. Geometricians conceive the line subdivided into six points. The French line answers to the English barleycorn.

LINEAR numbers, in mathematics, such as have relation to length only; such is a number which represents one side of a plane figure. If the plane figure be a square, the linear number is called a root.

Linear problem, that which may be solved geometrically, by the intersection of two right lines. This is called a simple problem, and is capable but of one solution.

LINEN, in commerce, a well-known kind of cloth, chiefly made of flax. See Linum, and Weaving.

LING. See Gadus.

LINIMENT. See Pharmacy.

LINNÆA, a genus of the class and order didynamia angiospermia. The cal. is double; the cor. bell-shaped; the berry dry, three-celled. There is one species, a herb of Sweden.

LINNET. See Fringillia.

LINSEED, the seed of the plant linum. See Linum.

LINSPINS, in the military art, small pins of iron, which keep the wheel of a cannon or waggon on the axletree; for when the end of the axle-tree is put through the nave, the linspin is put in, to keep the wheel from falling off.

LINT, the scrapings of linen; which is used in dressing wounds, and is made up in various forms, as tents, dossils, pledgets, &c. See Surgery.

LINUM, flax; a genus of the pentagynia order, in the pentandria class of plants; and in the natural method ranking under the 14th order, gruinales. The calyx is pentaphyllous; the petals are five; the capsule is quinquevalved and decemlocular; and the seeds are solitary. There are 25 species, of which the most remarkable are,

1. The usitatissimum, or common annual flax. 2. The perenne, or perennial Siberian flax, with umbellate clusters of large blue flowers. 3. The catharticum, or purging flax, a very small plant, not above four or five inches high; found wild upon chalky hills and in dry pleasure-grounds.

The first species is cultivated in the fields for the use of the manufactures. The second sort is chiefly ornamental. The virtue of the third species is expressed in its title: an infusion in water or whey of a handful of the fresh leaves, or a dram of them in substance when dried, is said to purge without inconvenience.

Of the cultivation of flax. A skilful flax-raiser always prefers a free, open, deep loam; and all grounds that produced the preceding year a good crop of turnips, cabbages, potatoes, barley, or broad clover; or have been formerly laid down rich, and kept for some years in pasture.

If the linseed is sown early, and the flax not allowed to stand for seed, a crop of turnips may be got after the flax that very year; the second year a crop of rye or barley may be taken; and the third year, grass-seeds are sometimes sown along with the linseed. Of preceding crops, potatoes and hemp are the best preparation for flax. If the ground is free and open, it should be but once ploughed, and that as shallow as possible, not deeper than two and a half inches. It should be laid flat, reduced to a fine garden mould by good harrowing, and all stones and sods should be carried off. Except a little pigeon's dung for cold or sour ground, no other dung should be used preparatory for flax; because it produces too many weeds, and throws up the flax thin and poor upon the stalk. Before sowing, the bulky clods should be broken, or carried off the ground; and stones, quickenings, and every other thing that may hinder the growth of the flax, should be carefully taken away. The brighter in colour, and heavier the seed is, so much the better; that which when bruised appears of a light or yellowish green, and fresh in the heart, oily, and not dry, and smells and tastes sweet, and not fusty, may be depended upon. Dutch seed of the preceding year's growth, for the most part, answers best; but it seldom succeeds if kept another year. It ripens sooner than any other foreign seed. Philadelphia seed produces fine lint and few bools, because sown thick, and answers best in wet cold soils.

The quantity of linseed sown should be proportioned to the condition of the soil; for if the ground is in good heart, and the seed sown thick, the crop will be in danger of falling before it is ready for pulling. The time for sowing linseed is from the middle of March to the end of April, as the ground and season answer; but the earlier the seed is sown, the less the crop interferes with the corn harvest. Late sown linseed may grow long, but the flax upon the stalk will be thin and poor.

Flax ought to be weeded, when the crop is about four inches long. If longer deferred, the weeders will also much break and bend the stalks, and they will perhaps never recover their straightness again; and when the flax grows crooked, it is more liable to be hurt in the rippling and swingling. Quicken grass should be taken up; for, being strongly rooted, the pulling of it always loosens a great deal of the lint. If there is an appearance of a settled drought, it is better to defer the weeding, than by that operation to expose the tender roots of the flax to the drought.

When the crop grows so short and branchy as to appear more seed than flax, it ought not be pulled before it is thoroughly ripe; but if it grows long and not branchy, the seed should be disregarded, and all the attention given to the flax. In the last case it ought to be pulled after the bloom has fallen, when the stalk begins to turn yellow, and before the leaves fall, and the bolls turn hard and sharp-pointed. When the stalk is small, and carries few bolls, the flax is fine; but the stalk of coarse flax is gross, rank, branchy, and carries many bolls. When the flax has fallen, and lies, such as lies ought to be immediately pulled, whether it has grown enough or not, as otherwise it will rot altogether. When parts of the same field grow unequally, so that some parts are ready for pulling before other parts, only what is ready should be pulled, and the rest should be suffered to stand till it ripens. The flax-raiser ought to be at pains to pull and keep by itself, each different kind of lint which he finds

in his field; what is both long and fine, by itself; what is both long and coarse, by itself; what is both short and fine, by itself; what is both short and coarse by itself; and in like manner every other kind by itself that is of the same size and quality.

If the flax is more valuable than the seed, it ought by no means to be stacked up; for its own natural juice assists it greatly in the watering; whereas, if kept long unwatered, it loses that juice, and the harle adheres so much to the boon, that it requires longer time to water, and even the quality of the flax becomes harsher and coarser. Besides, the flax stacked up is in great danger from vermin and other accidents; the water in spring is not so soft and warm as in harvest; and near a year is lost of the use of the lint; but if the flax is so short and branchy as to appear most valuable for seed, it ought, after pulling, to be stacked and dried upon the field, as is done with corn; then stacked up for winter, rippled in spring; and the seed should be well cleaned from bad seeds, &c

If the flax is to be regarded more than the seed, it should, after pulling, be allowed to lie some hours upon the ground to dry a little, and so gain some firmness, to prevent the skin or harle, which is the flax, from rubbing off in the rippling; an operation which ought by no means to be neglected, as the bolls, if put into the water along with the flax, breed vermin there, and otherwise spoil the water. The bools also prove very inconvenient in the grassing and breaking. The handfuls for rippling should not be great, as that endangers the lint in the rippling comb. After rippling, the flax-raiser will perceive, that he is able to assort each size and quality of the flax by itself more exactly than he could before.

In watering, a running stream wastes the lint, makes it white, and frequently carries it away. Lochs, by the great quantity and motion of the water, also waste and whiten the flax, though not so much as running streams. Both rivers and lochs water the flax quicker than canals. The greater way the river or brook has run, the softer, and therefore the better, will the water be. Springs, or short runs from hills, are too cold, unless the water is allowed to stand long in the canal. Water from coal or iron is very bad for flax. A little of the powder of galls thrown into a glass of water will discover if it comes from minerals of that kind, by turning it into a dark colour, more or less tinged in proportion to the quantity of metal it contains. When the water is brought to a proper heat, small plants will be rising quickly in it, numbers of small insects and reptiles will be generating there, and bubbles of air rising on the surface. If no such signs appear, the water is scarcely warm enough, or is otherwise unfit for flax. Moss-holes, when neither too deep nor too shallow, frequently answer well for watering flax, when the water is proper, as before described. The proper season for watering flax is from the end of July to the end of August. The doing this as soon as possible after pulling is very advantageous. The flax being sorted after rippling, as before mentioned, should next be put in beets, never larger than a man can grasp with both his hands, and tied very slack with a band of a few stalks. Dried rushes answer exceedingly well for binding flax, as they do not rot in the water, and may be dried and kept for use again. The beets should be put into the canals slope-ways, or half-standing upon end, the root end uppermost. Upon the crop ends, when uppermost, vermin frequently breed, destructive of the flax, which are effectually prevented by putting the crop end downmost. The whole flax in the canal ought to be carefully covered from the sun with divots; the grassy side of which should be next the flax, to keep it clean. If it is not thus covered, the sun will discolour the flax, though quite covered with water. If the divots are not weighty enough to keep the flax entirely under water, a few stones might be laid above them; but the flax should not be pressed to the bottom.

When the flax is sufficiently watered, it feels soft to the gripe, and the harle parts easily with the boon or show, which last is then become brittle, and looks whitish. When these signs are found, the flax should be taken out of the water, beet after beet; each gently rinsed in the water, to cleanse it of the filth which has gathered about it in the canal; and as the lint is then very tender, and the beet slackly tied, it must be carefully and gently handled. Great care ought to be taken that no part be overdone: and as the coarsest waters soonest, if different kinds are mixed together, a part will be rotted, when the rest is not sufficiently watered. When lint taken out of the canal is not found sufficiently watered, it may be laid in a heap for twelve, eighteen, or twenty-four hours, which will have an effect like more watering; but this operation is nice, and may prove dangerous in unskilful hands. After the flax is taken out of the canal, fresh lint should not be put a second time into it, until the former water is run off, and the canal cleaned, and supplied with a fresh quantity of water.

Short heath is the best field for grassing flax; as, when wet, it fastens to the heath, and is thereby prevented from being blown away by the wind. The heath also keeps it a little above the earth, and so exposes it more equally to the weather. When such heath is not to be got, links or clean old lea-ground is the next best. Long-grass grounds should be avoided, as the grass growing through the lint frequently spots, tenders, or rots it; and grounds exposed to violent winds should also be avoided. The flax, when taken out of the water, must be spread very thin upon the ground; and being then very tender, it must be gently handled. The thinner it is spread the better, as it is then more equally exposed to the weather. But it ought never to be spread during a heavy shower, as that would wash and waste the harle too much, which is then excessively tender, but soon after becomes firm enough to bear the rains, which, with the open air and sunshine, cleans, softens, and purifies the harle to the degree wanted, and makes it blister from the boon. In short, after the flax has got a little firmness by being a few hours spread in dry weather, the more rain and sunshine it gets the better. If there is little danger of high winds carrying off the flax, it will be much the better for being turned about once a week. If it is not to be turned, it ought to be very thin spread. The spreading of flax and hemp, which requires a great deal of ground, enriches it greatly. The flax-raiser should spread his first row of flax at the end of the field opposite to the point whence the most violent wind commonly comes, placing the root ends foremost. He makes the root ends of every other row overlap the crop ends of the former row three or four inches, and binds down the last row with a rope;

by which means the wind does not easily get below the lint to blow it away; and as the crop ends are seldom so fully watered as the root ends, the overlapping has an effect like giving the crop ends more watering.

A dry day ought to be chosen for taking up the flax; and if there is no appearance of high wind, it should be loosed from the heath or grass, and left loose for some hours, to make it thoroughly dry.

As a great quantity of flax can scarcely be all equally watered and grassed, and as the different qualities will best appear at lifting the flax off the grass; therefore at that time each different kind should be gathered together, and kept by itself; that is, all of the same colour, length, and quality.

The smaller the beets lint is made up in, the better for drying, and the more convenient for stacking, housing, &c. and in making up these beets, as in every other operation upon flax, it is of great consequence that the lint be laid together as it grew, the root ends together, and the crop ends together. The profit on five acres of flax raised in Shropshire, was 46*l.* 4*s.* 5*d.*

LION. See Felis.

LIPARIA, a genus of the diadelphia decandria class and order. The cal. is five-cleft; cor. wings two-lobed, below; stam. the larger, with three shorter teeth; legume ovate. There are four species, shrubs of the Cape.

LIPPIA, a genus of the didynamia gymnospermia class and order. The cal. is four-toothed; the caps. one-celled, three-valved, two-seeded; seed one, two-celled. There are five species, shrubs of America.

LIQUEFACTION. See Fluidity.

LIQUIDS, expansion of. See Expansion.

LIQUIDAMBAR, Sweet-gum tree, a genus of the polyandria order, in the monœcia class of plants; and in the natural method ranking with those of which the order is doubtful. The male calyx is common and triphyllous; there is no corolla, but numerous filaments; the male calyces are collected into a spherical form, and tetraphyllous; there is no corolla; but seven styles, and many bivalved and monospermous capsules, collected into a sphere. There are only two species, both deciduous, viz. 1. The styraciflua, or the Virginia or maple-leaved liquidambar; a native of the rich moist parts of Virginia and Mexico. It will shoot in a regular manner to thirty or forty feet high, having its young twigs covered with a smooth light-brown bark, while those of the older are of a darker colour. The flowers are of a kind of saffron-colour: they are produced at the ends of the branches the beginning of April, and sometimes sooner; and are succeeded by large round brown fruit, which looks singular, but is thought by many to be no ornament to the tree. 2. The peregrinum, Canada liquidambar, or spleenwort-leaved gale, is a native of Canada and Pennsylvania. The young branches of this species are slender, tough, and hardy. The flowers come out from the sides of the branches, like the former; and they are succeeded by small roundish fruit, which seldom ripens in England. These may be propagated either by seeds or layers.

The leaves of this tree emit their odoriferous particles in such plenty as to perfume the circumambient air; nay, the whole tree exudes such a fragrant transparent resin, as to have given occasion to its being taken for the sweet storax. (See Styrax.) These trees, therefore, are very proper to be planted singly in large opens, that they may amply display their fine pyramidal growth, or to be set in places near seats, pavilions, &c. The resin was formerly of great use as a perfume, and is at present no stranger in the shops.

LIQUORICE. See Glycirrhiza, and Materia Medica.

LIRIODENDRON, the Tulip-tree, a genus of the polygynia order, in the polyandria class of plants; and in the natural method ranking under the 52d order, coadunatæ. The calyx is triphyllous; there are nine petals; and the seeds imbricated in such a manner as to form a cone. There are two species; the tulipfera, is best known here, and is a deciduous tree, native of most part of America. It rises with a large upright trunk, branching forty or fifty feet high. The trunk, which often attains to a circumference of thirty feet, is covered with a grey bark. The leaves grow irregularly on the branches, on long footstalks. They are of a particular structure, being composed of three lobes, the middlemost of which is shortened in such a manner that it appears as if it had been cut off and hollowed at the middle. The two others are rounded off. They are about four or five inches long, and as many broad. The flowers are produced with us in July, at the ends of the branches. The number of petals of which each is composed, like those of the tulip, is six; and these are spotted with green, red, white, and yellow. The flowers are succeeded by large cones, which never ripen in England.

LISIANTHUS, a genus of the pentandria monogynia class and order. The cal. is keeled; cor. with ventricose tube and recurved division; stigma two-plated; caps. two-valved, two-celled. There are nine species, herbs of the West Indies.

LITA, a genus of the class and order pentandria monogynia. The cal. is five-cleft; cor. salver-shaped, long tube, five-cleft; caps. one-celled, two-valved; seeds numerous. There are two species, herbs of Guiana.

LITHOPHILA, a genus of the diandria monogynia class and order. The cal. is three leaved; cor. three-petalled; nect. two-leaved. There is one species, of no note.

LITHARGE, an oxide of lead. See Lead.

LITHOPHYTA, the name of Linnæus's third order of vermes.

LITHOSPERMUM, gromwell: a genus of the monogynia order, in the pentandria class of plants; and in the natural method ranking under the 41st order, asperifoliæ. The corolla is funnel-shaped, with the throat perforated and naked; the calyx quinquepartite. There are 12 species; but the only remarkable ones are the officinale or common gromwell, and the arvensa or bastard alkanet. Both these are natives of Britain; the former growing in dry gravelly soil, the latter in corn-fields.

LITHOTOMY. See Surgery.

LITTORELLA, a genus of the monœcia tetrandria class and order. The male cal. is four-leaved; cor. four-cleft; stam. long. No female cal.; cor. four-cleft, seed a nut. There is one species.

LIVER. See Anatomy.

LIVERY *of seisin*, in law, signifies delivering the possession of lands, &c. to him who has a right to them. There are two kinds of livery and seisin; livery in law

where the feoffer being in view of the land, house, or other thing granted, says to the feoffee, on delivery of the deed, "I give to you yonder land, &c. to hold to you and to your heirs, so go into the same, and take possession accordingly." And livery in deed, is where the parties, or the attorneys by them authorised, coming to the door of the house, or upon some part of the land, declare the occasion of their meeting before witnesses, read the deed, or its contents, and in case it be made by attorney, the letter of attorney is also read, after which, if the delivery is of a house, the grantor, or his attorney, takes the ring, key, or latch belonging to the door, or if it be a land, a turf, or clod of earth, and a twig of one of the trees, and delivering them with the deed to the grantee or his attorney, says, "I A. B. do hereby deliver to you possession and seisin of this messuage or tenement, &c. to hold to you, your heirs and assigns, according to the purport, true intent, and meaning of this indenture, or deed of feoffment." After which the grantee enters first alone, and shutting the door, and then opening it, lets in others.

Since the making the statute of uses, livery and seisin are not so much used as formerly; for a lease and release, a bargain and sale by deed inrolled, are sufficient to vest the grantee with possession, without the formality of livery.

LIVERYMEN of London, are a number of men selected from among the freemen of each company. Out of this body, the common council, sheriff, and other superior officers for the government of the city are elected, and they alone have the privilege of giving their votes for members of parliament; from which the rest of the citizens are excluded.

LIVES, or insurance of lives. See INSURANCE, and LIFE.

LIXIVIUM. See PHARMACY.

LIZARD. See LACERTA.

LOAD, or LODE, in mining, a word used especially in the tin-mines, for any regular vein or course, whether metallic or not; but most commonly load means a metallic vein. It is to be observed, that mines in general are veins within the earth, whose sides receding from or approaching to each other, make them of unequal breadths in different places, sometimes forming large spaces, which are called holes; these holes are filled like the rest with substances, which whether metallic, or of any other nature, are called loads. When the substances forming these loads are reducible to metal, the loads are by the English miners said to be alive, otherwise they are termed dead loads.

The load is frequently intercepted by the crossing of a vein of earth or stone, or some other metalline substance; in which case it generally happens, that one part of the load is moved to a considerable distance on one side. This load is by the miners termed a flooking, and the part of the load which is moved, is by them said to be heaved. This fracture or heave of a load, according to Mr. Price, is produced by a subsidence of the strata from their primary positions, which he supposes to have been horizontal or parallel to the surface of the earth, and therefore should more properly be called a depression than a heave. This heaving of the load would be an inexpressible loss to the miner, did not experience teach him that as the loads always run on the sides of the hills, so the part heaved is always moved toward the descent of the hill; so that the miner, working toward the ascent of the hill, and meeting a flooking, considers himself as working in the heaved part; wherefore, cutting through the flooking, he works upon its back up the ascent of the hill, till he recovers the load, and vice versa.

LOAMS. See HUSBANDRY.

LOANS, in political economy, sums of money, generally of large amount, borrowed from individuals or public bodies, for the service of the state. They are either compulsory, in which case they may be more properly termed requisitions; or voluntary, which is the only mode that can be frequently resorted to with advantage. Loans are sometimes furnished by public companies as a consideration for peculiar privileges secured to them; but are much more commonly advanced by individuals on a certain interest being allowed for the use of the money, either for a term of years, or until the principal shall be repaid.

The practice of borrowing money, for defraying part of the extraordinary expenses in time of war, had been adopted in other countries long before it was introduced into Great Britain; but it has been carried to a far greater extent here than by any other state: and the facility with which the government has been enabled to raise the largest sums, has arisen entirely from the strict punctuality with which it has constantly made good all pecuniary engagements. The chancellor of the exchequer is the officer who usually conducts negotiations of this kind on the part of the government, and the agreement is afterwards confirmed by parliament; the governor and company of the bank of England, have of late years been usually appointed receivers of the contributions, for which they have an allowance, at a certain rate per million; and the sums received by them are paid into the exchequer in the name of the chief cashier of the bank. The money appropriated to pay the interest or annuities, is issued at the receipt of the exchequer to the chief cashier of the bank upon account, and he is enjoined to pay the annuities, and render his account in due course. The bank detain their allowance for receiving the contributions out of the sum received, and likewise what they have allowed as discount to those subscribers who advanced their money before the times fixed for the several instalments.

When the parliament has voted the supplies, and the extent of the loan found necessary is determined, a communication is usually made to the bank or stock exchange stating the particular stock on which the loan is to be made, and fixing a day for those who intend to bid for it to wait on the minister with their proposals; in the mean time each person forms his list of friends who are to take different proportions with him in case he succeeds. When the day comes, each party offers as low as he thinks he can venture with a fair prospect of profit, and the lowest offer is generally accepted. The only step to be taken by those who are not of the number just mentioned, and who may wish to take a share in the transaction, is to apply to one of the subscribers for a part of his subscription, which at first may sometimes be had without any premium, or for a very small one, for it cannot be presumed

that any small number of men, who have subscribed for the whole sum to be raised, intend, or can keep it, but that they propose to include in their subscriptions a great number of their connections and acquaintance. Sometimes the subscription lies open to the public at the bank, as in the instance of the loan of eighteen millions for the service of the year 1797, and then every person is at liberty to subscribe what he thinks proper; and if upon casting up the whole, there is a surplus subscribed, which has generally been the case, the sum each person has subscribed, is reduced in an equal proportion, so as to make in the whole the sum fixed by parliament.

As soon as conveniently may be, after the subscription is closed, receipts are made out, and delivered to the subscribers, for the several sums by them subscribed; and for the conveniency of sale, every subscriber of a considerable sum has sundry receipts for different proportions of his whole sum, by which means he can readily part with what sum he thinks proper; and a form of assignment is drawn upon the back of the receipt, which being signed and witnessed, transfers the property to any purchaser. The deposit is generally ten per cent. and is made at or about the time of subscribing; the second payment is about a month after, and so on till the whole is paid in, each instalment being usually either ten or fifteen per cent. Those subscribers who choose to pay the whole sum before the appointed days of payment, are allowed discount at an agreed rate per cent. on the sum paid in advance, from the time of such payment to the period when the whole is required to be paid in by instalments. Those who do not complete the payment of the sum they have subscribed for, forfeit the part they have paid; and this is the case according to the acts of parliament, if the money is not paid by the days appointed; but payments are sometimes received after the appointed days on paying certain fees to the clerk.

Loans are usually raised upon either redeemable or irredeemable annuities. The former are those which according to the conditions of the acts by which they are created, government may redeem without the consent of the proprietors, by discharging the debt at par; the latter are such as being granted for specific terms, cannot be redeemed without the consent of the proprietors. The various debts that have been incurred at different periods by loans on either of these species of annuities, constitute the funded debt of the nation; that is, the debt which has been secured upon certain funds, created by parliament, and appropriated to the payment of the annual interest on the sums borrowed. The constant hope of being able at a future period to redeem the debts contracted, has induced the government generally to prefer raising money on annuities redeemable at par; and the disadvantage which might arise to the stock-holder from being paid off at par, if his principal bore a high rate of interest, has always made those who advance money on loans prefer a large capital bearing a low rate per cent. though it may actually produce a somewhat less annual interest than would have been given on a capital equal to the sum advanced: the great speculations which are carried on in the public funds are also a strong inducement to prefer advancing money on these conditions, which have contributed so much to increase the nominal magnitude of the national debt.

The terms of all the public loans which have been raised from the commencement of the funding system, have been collected by Mr. J. J. Grellier, who observes, that "the economy or extravagance of every transaction of this kind depends on its correspondence or disagreement with the price of the public funds, and the current rate of interest at which money could be obtained on good security at the time the bargain was concluded; and consequently, a loan on which the highest interest is paid, may have been obtained on the best terms that could possibly be made at the time it was negociated." The interest paid, however, forms the real burthen of each loan to the country, and is the circumstance to be chiefly attended to in all comparisons of the advantage or disadvantage of the terms on which the public debts have been contracted at different periods.

From the difference in the terms of the loan, with respect to the capital created, the rate of interest it bears, and the different periods of the terminable annuities which have been granted with most of the loans, it is evident, that in order to form a proper comparison of the rate of interest paid for the money borrowed at different periods, the various conditions must be brought into some degree of uniformity; and the most obvious mode of doing this is, by converting that part of the interest which consists of terminable annuities into equivalent perpetual annuities; that is, into the additional interest, which must have been paid in lieu of such terminable annuities.

The rate of interest at which such conversion is made affects the result in some instances very materially; thus, the perpetual annuity, which is equal to an annuity of 10*l.* for 21 years, is, at 3 per cent. 4*l.* 12*s.* 5*d.* but at 5 per cent. 6*l.* 8*s.* 2*d.*; and the perpetual annuity equal to an annuity of 10*l.* for 60 years, which at 3 per cent. is 8*l.* 6*s.* is at 5 per cent. 9*l.* 9*s.* 3*d.* from which it is evident, that, if the terminable annuities, granted at different periods, are all valued at the same rate of interest, the comparison will by no means be just; for if a high rate is adopted, the loans which have been obtained at the lowest interest will be set in an unfavourable view; and if, on the contrary, they are all valued at a low rate, the charge of those loans, for which the highest interest is paid, will appear less than it really is. Nor is a medium or average rate more proper for exhibiting the real difference in the terms on which the several loans have been obtained. The least objectionable mode appears to be to convert the terminable annuities into perpetual annuities, according to the current rate of interest at the time when the annuities were granted, as it is upon the rate of interest that the proportionate value of an annuity for a certain term to the perpetuity depends; and in forming the following statements, the conversion has been made at the interest produced by money invested in the three per cents. according to the price of this stock at the times when the terms of the respective loans were settled: for, though by this means, the rate is, in each case, rather lower than it would have been had the interest produced by 4 or 5 per cent. stock been adopted, it is most probable, from the nature of the principal loans, that the stock which must have been given in lieu of a long annuity, would chiefly have been three per cents.; and, therefore, the interest equivalent to the long annuity should be found according to the interest produced by this stock. It may also be

proper to remark, that, as the terminable annuities have mostly been granted for a long term, and form but a small part of the whole interest, particularly on the loans of the last war, the difference of a quarter or even half per cent. in the rate at which they are valued has in general but little effect on the whole rate per cent. of the loan. Thus, if the long annuity of the loan of 14,500,000*l.*, in 1797, is valued at 6 per cent. (being the interest produced by 3 per cents. at that time) it makes the whole rate per cent. 6*l.* 6*s.* 10*d.*; but, if the long annuity is valued at $5\frac{3}{4}$ per cent. it will be 6*l.* 6*s.* $9\frac{3}{4}$*d.*; at $5\frac{1}{2}$ per cent. 6*l.* 6*s.* $9\frac{1}{4}$*d.*; and, at 5 per cent. 6*l.* 6*s.* $8\frac{1}{2}$*d.* On the loan of 1798, the difference would be still less.

Till the last war, the lottery generally formed part of the terms of the loan; every subscriber of a certain sum towards the latter being entitled to a certain number of tickets, at 10*l.* each, the price at which the lottery-scheme is usually formed. As the whole profits of the lotteries were thus given up to the subscribers, a part of the money advanced must be considered as equivalent to the sum which government would otherwise have received for the lottery, and is therefore to be deducted from the whole sum advanced on the loan. This profit is variable, but has generally been taken at the average of 2*l.* 10*s.* per ticket; making, on a lottery of 50,000 tickets, 125,000*l.* to be deducted from the sum advanced, in estimating the rate of interest paid thereon.

There are some other circumstances which affect the interest paid: such as the discount allowed for prompt payment, the different periods of the instalments, and the times from which the annuities commence; but as these drawbacks do not in general amount to any considerable sum, in comparison with the whole amount of the loan, they do not materially augment the rate of interest; and as they more or less affect all the loans, they are of still less importance in a comparative view. In the following statement, however, a deduction is made on the loans of 18,000,000*l.* in 1796 and 1797, on account of the advantage allowed with respect to the time from which the annuities commenced, being greater than usual.

It is unnecessary to enter into a particular investigation of the interest paid for the money borrowed in the infancy of the funding system, as the first loans differed materially from those of subsequent periods, in being raised wholly on terminable annuities, and in having a particular fund assigned for each loan, by the supposed adequateness or insufficiency of which the interest required by the lenders was frequently influenced, as well as by other causes, which have since ceased to exist.

During the reign of queen Anne, loans were chiefly raised on annuities for 99 years, till 1711, when, by the establishment of the South Sea company, a variety of debts were consolidated and made a permanent capital, bearing 6 per cent. interest. About this period lotteries were also frequently adopted for raising money for the public service, under which form a considerable premium was given, in addition to a high rate of interest. This mode of raising money was followed in 1712, 1713, and 1714. In the latter year, though the interest paid was equal to only 5*l.* 7*s.* 2*d.* per cent. on the sum borrowed, the premium allowed was upwards of 34*l.* per cent.; but as peace was restored, and the legal rate of interest had been reduced to 5 per cent. it seems that a larger premium was allowed, for the sake of appearing to borrow at a moderate rate of interest.

In the reign of George I. the interest on a considerable part of the public debts was reduced to 5 per cent. and the few loans that were raised were comparatively of small amount; that of the year 1720 was obtained at little more than 4 per cent. interest.

About 1730 the current rate of interest was $3\frac{1}{2}$ per cent.; and in 1736, government was enabled to borrow at 3 per cent. per annum. The extraordinary sums necessary for defraying the expenses of the war which began in 1739, were at first obtained from the sinking fund and the salt duties; a payment from the bank, in 1742, rendered only a small loan necessary in that year, which was obtained at little more than 3 per cent. interest. In the succeeding years the following sums were raised by loans;

	Sum borrowed.	Interest.		
1743	*L* 1,800,000	*L* 3	8	4
1744	1,800,000	3	6	10
1745	2,000,000	4	0	7
1746	2,500,000	5	5	1
1747	4,000,000	4	8	0
1748	6,300,000	4	8	0
	Loans of the seven years war.			
1756	2,000,000	3	12	0
1757	3,000,000	3	14	3
1758	5,000,000	3	6	5
1759	6,600,000	3	10	9
1760	8,000,000	3	13	7
1761	12,000,000	4	1	11
1762	12,000,000	4	10	9
1763	3,500,000	4	4	2
	Loans of the American war.			
1776	2,000,000	3	9	8
1777	5,000,000	4	5	2
1778	6,000,000	4	18	7
1779	7,000,000	5	18	10
1780	12,000,000	5	16	8
1781	12,000,000	5	11	1
1782	13,500,000	5	18	1
1783	12,000,000	4	13	9
1784	6,000,000	5	6	11
	Loans of the war with the French republic.			
1793	4,500,000	4	3	4
1794	11,000,000	4	10	7
1795	18,000,000	4	15	8
1796	18,000,000	4	14	9
1796	7,500,000	4	12	2
1797	18,000,000	5	14	1
1797	14,500,000	6	6	10
1798	17,000,000	6	4	9
1799	3,000,000	5	12	5
1799	15,500,000	5	5	0
1800	20,500,000	4	14	2
1801	28,000,000	5	5	5
	Loans of the war with the French empire.			
1803	12,000,000	5	2	0
1804	14,500,000	5	9	2
1805	22,500,000	5	3	2
1806	20,000,000	4	19	7

LOASA, a genus of the polyandria monogynia class and order. The cal. is five-leaved; cor. five-petalled;

nect. five-leaved; caps. turbinate, one-celled, three-valved, many-seeded. There is one species, an annual of South America.

LOBE. See Anatomy.

LOBELIA, cardinal-flower, a genus of the monogamia order, in the syngenesia class of plants, and in the natural method ranking under the 29th order, companaceæ. The calyx is quinquefid; the corolla monopetalous and irregular; the capsule inferior, bilocular or trilocular. There are 42 species, but only four of them are cultivated in our gardens, two of which are hardy herbaceous plants for the open ground, and two shrubby plants for the stove. They are all fibrous-rooted perennials, rising with erect stalks from two to five or six feet high, ornamented with oblong, oval, spear-shaped, simple leaves, and spikes of beautiful monopetalous, somewhat ringent, five-parted flowers, of scarlet, blue, and violet colours. They are easily propagated by seeds, offsetts, and cuttings of their stalks. The tender kinds require the common treatment of other exotics. They are natives of America, from which their seeds must be procured.

The root of the species called the syphilitica (see Plate LXXXIV. Nat. Hist. fig. 252.) is an article of the materica medica. This species grows in most places in Virginia, and bears our winters. It is perennial, has an erect stalk three or four feet high, blue flowers, a milky juice, and a rank smell. The root consists of white fibres about two inches long, resembles tobacco in taste, which remains on the tongue, and is apt to excite vomiting. It is used by the North American Indians as a specific in the venereal disease. The benefit, however, to be derived from this article has not, as far as we know, been confirmed either in Britain or by the practitioners in Virginia.

LOCAL, in law, something fixed to the freehold, or tied to a certain place: thus, real actions are local, since they must be brought in the country where they lie, and local customs are those peculiar to certain countries and places.

Local problem, among mathematicians, such a one as is capable of an infinite number of different solutions, by reason that the point which is to resolve the problem may be indifferently taken within a certain extent, as suppose any where within such a line, within suce a plane figure, &c. which is called a geometric locus, and the problem is said to be a local or indetermined one.

A local problem may be either simple, when the point sought is in a right light; plane, when the point sought is in the circumference of a circle; solid, when the point required is in the circumference of a conic section; or lastly, sursolid, when the point is in the perimeter of a line of the second gender, or of a higher kind, as geometers call it.

LOCHIA. See Midwifery.

LOCK, a well-known instrument, and reckoned the masterpiece in smithery; a great deal of art and delicacy being required in contriving and varying the wards, spring, bolts, &c. and adjusting them to the places where they are to used, and to the various occasions of using them. From the various structure of locks, accommodated to their different intentions, they acquire various names. Those placed on outer doors are called stock-locks; those on chamber-doors, spring-locks; those on trunks, trunk-locks, padlocks, &c. Of these the spring-lock is the most considerable, both for its frequency and the curiosity of its structure.

A treatise upon this subject has been published by Mr. Joseph Bramah, who begins with observing, that the principle on which all locks depend, is the application of a lever to an interior bolt, by means of a communication from without; so that, by means of the latter, the lever acts upon the bolt, and moves it in such a manner as to secure the lid or door from being opened by any pull or push from without. The security of locks in general, therefore, depends on the number of impediments we can interpose betwixt the lever (the key) and the bolt which secures the door; and these impediments are well known by the name of wards, the number and intricacy of which alone are supposed to distinguish a good lock from a bad one. If these wards, however, do not in an effectual manner preclude the access of all other instruments besides the proper key, it is still possible for a mechanic of equal skill with the lock-maker to open it without the key, and thus to elude the labour of the other. "As nothing (says Mr. Bramah) can be more opposite in principle to fixed wards than a lock which derives its properties from the motion of all its parts, I determined that the construction of such a lock should be the subject of my experiment." In the prosecution of this experiment, he had the satisfaction to find that the least perfect of all his models fully ascertained the truth and certainty of his principle. The exclusion of wards made it necessary to cut off all communication between the key and the bolt; as the same passage which (in a lock simply constructed) would admit the key, might give admission likewise to other instruments. The office, therefore, which in other locks is performed by the extreme point of the key, is here assigned to a lever, which cannot approach the bolt till every part of the lock has undergone a change of position. The necessity of this change to the purposes of the lock, and the absolute impossibility of effecting it otherwise than with the proper key, are the points to be ascertained.

Plate LXXIX. Lock and Loom, fig. 4, represents a mortice lock, made under the patent which Mr. Stansbury took out in 1805, for various improvements in locks, in which A is the spring-latch, as in common; the end B of this is bent, and has a frame D screwed to it, carrying a roller E; against this roller a wedge F called a pusher, shown separately in fig. 5, acts; the spindle G on which this pusher is fixed, slides through holes in the side-plate of the lock, so as to have no shake, and on each end is fastened a handle; by this arrangement it is plain that when the handle of the wedge is pushed from without the door, its wedge E will act against the roller E, fig. 4, draw back the bolt A, and release the door; a continuation of the same motion opens it. The operations from within the room are the same, except that the handle of the pusher must be pulled instead of pushed; but as it is on the other end of the spindle, the operation on the wedge and bolt is the same. For the convenience of persons not acquainted with the new method, the bolt may be drawn back by turning the handle, as in the common lock. H is a piece of metal, figs. 4 and 5, which has a round collar a above, and another b beneath, which work in holes in the two

side-plates of the lock, so as to turn easily round; this piece has a hole through it, large enough to admit the pusher to move up and down; and an opening in one side thereof admits the wedge F; so that when the spindle is turned round, one of the two arms *d e* of this piece, acts against the arm B of the bolt A, fig. 4, and draws back the bolt when the handle is turned, as in the common way. In order to reduce the friction against the bolt, in shutting the door, a small roller *a*, fig. 1, is applied to it. In lieu of the slip-bolt of common locks, Mr. Stansbury uses a piece I; which has a spindle going through the plate of the lock, and projecting from the door with a handle on it, by which its arm *f* can be moved up and down, when the door is to be bolted; this handle is turned so that the knob *g* on the arm *f* may fall in the notch cut in the bolt to receive it; this prevents the bolt being moved back by the pusher, till the arm *f* is first removed. There is a spring at the back of this arm, which pressing against the plate of the lock, by its friction keeps it from falling by accident. K is the main bolt of the lock; it is kept steady by a rectangular opening, through which a screw passes. The bolt is moved by a circular iron plate, moving round a pin *h*, which is riveted into a circular bridge N, screwed to the plate shown separately in fig. 3; this bridge has a circular opening *i* in it, through which a pin *c*, riveted to the plate L, moves; this pin takes into a notch in the bolt, so as to move it backwards and forwards, when the plate is turned round its centre. The locking part is performed thus: the wheel L has a certain number of holes drilled in it, as at *m*; the bridge has the same number of similar holes in it, and in the same position; each hole in the bridge has a small pin in it, which is pushed in by a slight spring *n n n*, fig. 3.; when the holes in the plate coincide with the holes in the bridge, the springs *n n n* push up the pins through the plate, and lock them both together. The key, fig. 2, has the same number of pins projecting from its lower end, as the pin-holes in the bridge, and in the same position; the length of the pins is the same as the thickness of the plate L, fig. 4. When it is to be unlocked, the key is introduced, and as it is turned round, it is pushed gently forward against the plate; when the pins and key come opposite the pin-holes and pins, the force applied overcomes the resistance of the springs *n n n*, the pins are pushed out, and the key gets hold of the plate L, when being turned round, it draws the bolt back by the pin *b*, fig. 3.

LOCUS GEOMETRICUS, denotes a line by which a local or indeterminate problem is solved.

A locus is a line, any point of which may equally solve an indeterminate problem. Thus, if a right line suffice for the construction of the equation, it is called *locus ad rectum;* if a circle, *locus ad circulum;* if a parabola, *locus ad parabolum;* if an ellipsis, *locus ad elipsin;* and so of the rest of the conic sections. The loci of such equations as are right lines, or circles, the ancients called plane loci; and of those that are parabolas, hyperbolas, &c. solid loci. But Wolfius, and others among the moderns, divide the loci more commodiously into orders, according to the number of dimensions to which the indeterminate quantities rise. Thus, it will be a locus of the first order, if the equation is $x = \frac{ay}{c}$; a locus of the second or quadratic order, if $y^2 = ax^2$, or $y^2 = a^2 - x^2$; a locus of the third or cubic order, if $y^3 = a^2x$, or $y^2 = ax^2 - x^3$, &c.

All equations whose loci are of the first order, may be reduced to some one of the four following formulas: 1. $y = \frac{bx}{a}$. 2. $y = \frac{bx}{a} + c$. 3. $y = \frac{bx}{a} c$. 4. $y = c - \frac{bx}{a}$: where the unknown quantity y, is supposed always to be freed from fractions, and the fraction that multiplies the other unknown quantity x, to be reduced to this expression, $\frac{b}{a}$, and all the known terms to c.

All loci of the second degree are conic sections, viz. either the parabola, the circle, ellipsis, or hyperbola: if an equation, therefore, is given, whose locus is of the second degree, and it is required to draw the conic section which is the locus thereof, first draw a parabola, ellipsis, or hyperbola; so as that the equations expressing the natures thereof may be as compound as possible, in order to get general equations or formulas, by examining the peculiar properties whereof we may know which of these formulas the given equation ought to have regard to; that is, which of the conic sections will be the locus of the proposed equation. This known, compare all the terms of the proposed equation with the terms of the general formula of that conic section, which you have found will be the locus of the given equation; by which means you will find how to draw the section which is the locus of the equation given.

If an equation, whose locus is a conic section, is given, and the particular section whereof it is the locus is required; all the terms of the given equation being brought over to one side, so that the other is equal to nothing, there will be two cases.

Case I. When the rectangle $x\, y$ is not in the given equation. 1. if either $y\, y$ or $x\, x$ is in the same equation, the locus will be a parabola. 2. If both $x\, x$ and $y\, y$ are in the equation with the same signs, the locus will be an ellipsis or a circle. 3. If $x\, x$ and $y\, y$ have different signs, the locus will be an hyperbola, or the opposite sections regarding their diameters.

Case II. When the rectangle $x\, y$ is in the given equation. 1. If neither of the squares $x\, x$ or $y\, y$, or only one of them, is in the same, the locus of it will be as hyperbola between the asymptotes. 2. If $y\, y$ and $x\, x$ is therein, having different signs, the locus will be an hyperbola regarding its diameters. 3. If both the squares $x\, x$ and $y\, y$ are in the equation, having the same signs, you must free the square $y\, y$ from fractions; and then the locus will be an hyperbola, when the square of $\frac{1}{2}$ the fraction multiplying $x\, y$, is equal to the fraction multiplying $x\, x$; an ellipsis, or circle, when the same is less; and an hyperbola, or the opposite sections, regarding their diameters, when greater.

LOCUST. See GRYLLUS.

LODGMENT, in military affairs, is a work raised with earth, gabions, fascines, woolpacks, or mantelets, to cover the besiegers from the enemy's fire, and to prevent their losing a place which they have gained, and are resolved, if possible, to keep. For this purpose, when a lodgment is to be made on the glacis, covered way, or in the breach, there must be great provision made of fascines, sand-bags, &c. in the trenches; and during the action, the poineers with fascines, sand-bags, &c. should

be making the lodgment, in order to form a covering in as advantageous a manner as possible from the opposite bastion, or the place most to be feared.

LOEFLINGIA, a genus of the class and order triandria monogynia. The calyx is five-leaved; corolla five-petalled; capsule one-celled, three-valved. There is one species, an annual of Spain.

LOESELIA, a genus of the didynamia angiospermia class of plants, the flower of which is monopetalous and quinquefid at the limb; the fruit is a trilocular capsule, with several angulated seeds in each cell. There is one species, a herb of South America.

LOG, in naval affairs, is a flat piece of wood, shaped somewhat like a flounder, with a piece of lead fastened to its bottom, which makes it stand or swim upright in the water. To this log is fastened a long line, called the log-line; and this is commonly divided into certain spaces 50 feet in length by knots, which are pieces of knotted twine inreeved between the strands of the line; which show, by means of a half-minute glass, how many of these spaces or knots are run out in half a minute. They commonly begin to be counted at the distance of about 10 fathoms or 60 feet from the log; so that the log, when it is hoven overboard, may be out of the eddy of the ship's wake before they begin to count: and for the ready discovery of this point of commencement, there is commonly fastened at it a red rag.

The log being thus prepared, and hoven overboard from the poop, and the line veered out by the help of a reel, as fast as the ship sails from it, will show how far the ship has run in a given time, and consequently her rate of sailing.

Hence it is evident, that as the distance of the knots bears the same proportion to a mile as half a minute does to an hour, whatever number of knots the ship runs in half a minute, the same number of miles she will run in an hour, supposing her to run with the same degree of velocity during that time; and therefore, in order to know her rate of sailing, it is the general way to heave the log every hour; but if the force or direction of the wind varies, and does not continue the same during the whole hour, or if there has been more sail set, or any sail handed in, by which the ship has sailed faster or slower than she did at the time of heaving the log, there must then be an allowance made for it accordingly.

Log-board, a table generally divided into five columns, in the first of which is entered the hour of the day; in the second the course steered: in the third, the number of knots run off the reel each time of heaving the log; in the fourth, from what point the wind blows; and in the fifth, observations on the weather, variation of the compass, &c.

Log book, a book ruled in columns like the log-board, into which the account on the log-board is transcribed every day at noon; whence, after it is corrected, &c. it is entered into the journal. See Navigation.

Log-wood, in commerce. See Hæmatoxylum.

Logwood is used by dyers for dying blacks and blues.

LOGARITHMIC, in general, something belonging to logarithms. See Logarithms.

Logarithmic curve. If on the line AN (Plate LXXVIII. Miscel., fig. 155.) both ways indefinitely extended, be taken, AC, CE, EG, GI, IL, on the right hand, and A *g*, *g* P, &c. on the left, all equal to one another, and if at the points P, *g*, A, C, E, G, I, L, be erected to the right line AN, the perpendiculars PS, *gd*, AB, CD, EF, GH, IK, LM, which let be continually proportional, and represent numbers, viz. AB, 1; CD, 10; EF, 100, &c. then shall we have two progressions of lines, arithmetical and geometrical: for the lines AC, AE, AG, &c. are in arithmetical progression, or as 1, 2, 3, 4, 5, &c. and so represent the logarithms to which the geometrical lines AB, CD, EF, &c. do correspond. For since AG is triple of the right line AC, the number GH shall be in the third place from unity, if CD is in the first; so likewise shall LM be in the fifth place, since AL = 5 AC. If the extremities of the proportionals S, *d*, B, D, F, &c. are joined by right lines, the figure SBML will become a polygon, consisting of more or less sides, according as there are more or less terms in the progression.

If the parts AC, CE, EG, &c. are bisected in the points *c*, *e*, *g*, *i*, *l*, and there are again raised the perpendiculars *cd*, *ef*, *gh*, *ik*, *lm*, which are mean proportionals between AB, CD; CD, EF, &c. then there will arise a new series of proportionals, whose terms beginning from that which immediately follows unity, are double of those in the first series, and the difference of the terms is become less, and approaches nearer to a ratio of equality, than before. Likewise, in this new series, the right lines AL, A*c*, express the distances of the terms LM, *cd*, from unity, viz. since AL is ten times greater than A*c*, LM shall be the tenth term of the series from unity; and because A*e* is three times greater than A*c*, *ef* will be the third term of the series if *cd* is the first, and there shall be two mean proportionals between AB and *ef*; and between AB and LM there will be nine mean proportionals. And if the extremities of the lines B*d*, D*f*, F*h*, &c. are joined by right lines, there will be a new polygon made, consisting of more but shorter sides than the last.

If, in this manner, mean proportionals are continually placed between every two terms, the number of terms at last will be made so great, as also the number of the sides of the polygon, as to be greater than any given number, or to be infinite; and every side of the polygon so lessened, as to become less than any given right line; and consequently the polygon will be changed into a curvelined figure: for any curve-lined figure may be conceived as a polygon whose sides are infinitely small and infinite in number. A curve described after this manner, is called logarithmical.

It is manifest, from this description of the logarithmic curve, that all numbers at equal distances are continually proportional. It is also plain, that if there are four numbers, AB, CD, IK, LM, such that the distance between the first and second, is equal to the distance between the third and fourth, let the distance from the second to the third be what it will, these numbers will be proportional. For because the distance AC, IL, are equal, AB shall be to the increment Ds, as IK is to the increment MT. Wherefore, by composition, AB : DC : IK : ML. And contrariwise, if four numbers are proportional, the distance between the first and second shall be equal to the distance between the third and fourth.

The distance between any two numbers, is called the logarithm of the ratio of those numbers; and, indeed, does not measure the ratio itself, but the number of terms in a

$\frac{n-1}{2}x^2 + n \times \frac{n-1}{2} \times \frac{n-2}{3}x^3$, &c. we shall have $1 + nx + n \times \frac{n-1}{2}x^2 + n \times \frac{n-1}{2} \times \frac{n-2}{3}x^3$, &c. $= \text{N}$.

But since n, from the nature of the logarithms, is here supposed indefinitely great, it is evident that the numbers connected to it by the sign — may all be rejected, as far as any assigned number of terms.

For as 1, 2, 3, &c. are indefinitely small in comparison to n, the rejecting of those numbers can very little affect the values to which they belong.

If, therefore, 1, 2, 3, &c. be thrown out of the factors $\frac{n-1}{2}, \frac{n-2}{3}, \frac{n-3}{4}$, &c. we shall have $1 + nx + \frac{n^2x^2}{2} + \frac{n^3x^3}{2.3} + \frac{n^4x^4}{2.3.4}$, &c. $= \text{N}$.

But $nx\ (=\text{L})$ is the hyperbolic logarithm of $(1+x)^n$, or N, by what has been before specified; and therefore $1 + \text{L} + \frac{\text{L}^2}{2} + \frac{\text{L}^3}{2.3} + \frac{\text{L}^4}{2.3.4}$, &c. $= \text{N} =$ number required.

Of the method of using a Table of Logarithms.—Having explained the method of making a table of the logarithms of numbers greater than unity, the next thing to be done is, to show how the logarithms of fractional quantities may be found. And, in order to this, it may be observed, that as we have hitherto supposed a geometric series to increase from an unit on the right hand, so we may now suppose it to decrease from an unit towards the left; and the indices, in this case, being made negative, will still exhibit the logarithms of the terms to which they belong.

Thus Log.	— 3	— 2	— 1	0	+ 1	+ 2	+ 3, &c.
Num.	$\frac{1}{1000}$	$\frac{1}{100}$	$\frac{1}{10}$	1	10	100	1000, &c.

Whence + 1 is the logarithm of 10, and — 1, the logarithm of $\frac{1}{10}$; + 2 the logarithm of 100, and — 2 the logarithm of $\frac{1}{100}$, &c.

And from hence it appears that all numbers, consisting of the same figures, whether they be integral, fractional, or mixed, will have the decimal parts of their logarithms the same.

Thus, the logarithm of 5874 being 3.7689339, the logarithm of $\frac{1}{10}, \frac{1}{100}, \frac{1}{1000}$, &c. part of it will be as follows:

Num.	Logarithms.
5 8 7 4	3.7 6 8 9 3 3 9
5 8 7.4	2.7 6 8 9 3 3 9
5 8.7 4	1.7 6 8 9 3 3 9
5.8 7 4	0.7 6 8 9 3 3 9
.5 8 7 4	—1.7 6 8 9 3 3 9
.0 5 8 7 4	—2.7 6 8 9 3 3 9
.0 0 5 8 7 4	—3.7 6 8 9 3 3 9

From this it also appears, that the index, or characteristic, of any logarithm, is always one less than the number of figures which the natural number consists of: and this index is constantly to be placed on the left hand of the decimal part of the logarithm.

When there are integers in the given number, the index is always affirmative; but when there are no integers, the index is negative, and is to be marked by a line drawn before it, like a negative quantity in algebra.

Thus, a number having 1, 2, 3, 4, 5, &c. integer places, the index of its log. is 0, 1, 2, 3, 4, &c. And a fraction having a digit in the place of primes, seconds, thirds, fourths, &c. the index of its logarithm will be — 1, — 2, — 3, — 4, &c.

It may also be observed, that though the indices of fractional quantities are negative, yet the decimal parts of their logarithms are always affirmative; and all operations are to be performed by them in the same manner as by negative and affirmative quantities in algebra.

In taking out of a table the logarithm of any number not exceeding 10000, we have the decimal part by inspection; and if to this the proper characteristic be affixed, it will give the complete logarithm required.

But if the number, whose logarithm is required, be above 10000, then find the logarithm of the two nearest numbers to it that can be found in the table, and say, as their difference : the difference of their logarithms : : the difference of the nearest number and that whose logarithm is required : the difference of their logarithms, nearly; and this difference being added to, or subtracted from, the nearest logarithm, according as it is greater or less than the required one, will give the logarithm required, nearly.

Thus, let it be required to find the logarithm of 367182.

The decimal part of 3671 is by the table .5647844; and of 3672 is .5649027;

$$\therefore \begin{array}{l}\text{The} \\ \text{log. of}\end{array} \left\{ \begin{array}{l} 367100 \text{ is } 5.5647844 \\ 367200 \text{ is } 5.5649027 \end{array} \right\}$$

$$\begin{array}{lll} \text{Their diff.} & 100 & .0001183 \text{ diff.} \end{array}$$

$$\begin{array}{l}\text{Nearest No.} \\ \text{Given No.}\end{array} \left\{ \begin{array}{l} 367200 \\ 367182 \end{array} \right.$$

$$18 \text{ diff.}$$

Therefore 100 : 0001183 :: 18 : 0000212.

And 5.5649027 — .0000212 = 5.5648815 = logarithm of 367182, nearly.

If the number consists both of integers and fractions, or is entirely fractional, find the decimal part of the logarithm as if all its figures were integral; and this, being prefixed to the proper characteristic, will give the logarithm required.

And if the given number is a proper fraction, subtract the logarithm of the denominator from the logarithm of the numerator, and the remainder will be the logarithm sought; which, being that of a decimal fraction, must always have a negative index.

And, if it is a mixed number, reduce it to an improper fraction, and find the difference of the logarithms of the numerator and denominator, in the same manner as before.

In finding the number answering to any given logarithm, the index, if affirmative, will always show how many integral places the required number consists of; and, if negative, in what place of decimal the first, or significant figure, stands; so that, if the logarithm can be found in the table, the number answering to it will always be had by inspection.

But, if the logarithm cannot be exactly found in the table, find the next greater, and the next less, and then say, As the difference of these two logarithms : the difference of the numbers answering to them : : the difference of the given logarithm, and the nearest tabular

logarithm : a fourth number; which added to, or subtracted from, the natural number answering to the nearest tabular logarithm, according as that logarithm is less or greater than the given one, will give the number required, nearly.

Thus, let it be required to find the natural number answering to the logarithm 5.5648815.

The next less and greater logarithms, in the table, are

5.5647844	The numbers	367100
5.5649027	answering	367200
Their diff. .0001183		100

And 55649027 — 5.5648815 = 0000212.

Therefore .0001183 : 100 : : 0000212 : 18 nearly.

Whence 367200 — 18 = 377182 = number required.

The Use and Application of Logarithms.—It is evident, from what has been said of the construction of logarithms, that addition of logarithms must be the same thing as multiplication in common arithmetic; and subtraction in logarithms the same as division; therefore, in multiplication by logarithms, add the logarithms of the multiplicand and multiplier together, their sum is the logarithm of the product.

		num.	logarithms.
Example.	Multiplicand	8.5	0.9294189
	Multiplier	10	1.0000000
	Product	85	1.9294189

And in division, subtract the logarithm of the divisor from the logarithm of the dividend, the remainder is the logarithm of the quotient.

		num.	logarithms.
Example.	Dividend	9712.8	3.9873444
	Divisor	456	2.6589648
	Quotient	21.3	1.3283796

To find the Complement of a Logarithm.—Begin at the left hand, and write down what each figure wants of 9, only what the last significant figure wants of 10; so the complement of the logarithm of 456, viz. 2.6589648, is 7.3410352.

In the Rule of Three. Add the logarithms of the second and third terms together, and from the sum subtract the logarithm of the first, the remainder is the logarithm of the fourth. Or, instead of subtracting a logarithm, add its complement, and the result will be the same.

To raise Powers by Logarithms.—Multiply the logarithm of the number given, by the index of the power required, the product will be the logarithm of the power sought.

Example. Let the cube of 32 be required by logarithms. The logarithm of 32 = 1.5051500, which multiplied by 3, is 4.5154500, the logarithm of 32768, the cube of 32. But in raising powers, viz. squaring, cubing, &c. of any decimal fraction by logarithms, it must be observed, that the first significant figure of the power be put so many places below the place of units, as the index of its logarithm wants of 10, 100, &c. multiplied by the index of the power.

To extract the Roots of Powers by Logarithms.—Divide the logarithm of the number, by the index of the power, the quotient is the logarithm of the root sought.

To find Mean Proportionals between any two numbers. Subtract the logarithm of the least term from the logarithm of the greatest, and divide the remainder by a number more by one than the number of means desired then add the quotient to the logarithm of the least term (or subtract it from the logarithm of the greatest continually, and it will give the logarithms of all the mean proportionals required.

Example. Let three mean proportionals be sought, between 106 and 100.

Logarithm of 106 = 2.0253059
Logarithm of 100 = 2.0000000

Divide by 4)0.0253059(0.0063264.75

Log. of the least term 100 added		2.0000000
Log. of the 1st mean	101.4673846	2.0063264.75
Log. of the 2d mean	102.9563014	2.0126529.5
Log. of the 3d mean	104.4670483	2.0189794.25
Log. of the greatest term	106.	2.0253059.

LOGIC. The professed business of logic is to express the nature of the human mind, and the proper manner of conducting its several powers, in order to the attainment of truth and knowledge.

Those, therefore, who have treated expressly of this subject, have endeavoured first to define and describe the several faculties and operations of the human mind, as perception, judgment, memory, invention, &c. They next proceed to lay down rules for correct reasoning and argument. Every act of the judgment they term a *proposition*, and all propositions are either affirmative or negative. All questions or arguments they reduce to syllogisms, that is, from two axioms or propositions (called *terms*, in the technical language) laid down, they deduce a third, or conclusion, and the previous propositions they divide into major and minor. Thus, let the question be, *Whether God is an intelligent being?* Here the major or principal propositions proceeds from the word intelligent, and the minor respects God. They would then arrange the syllogism as follows:

Maj. To dispose things in right and perfect order is the work of an intelligent Being:
Min. But God has disposed creation in right and perfect order;
Conclusion. Therefore God is an intelligent Being.

They next class or arrange the different kinds of syllogisms according to the nature of them. Propositions are not only affirmative and negative, but they are also particular or universal. Hence syllogisms will vary not only as the major or minor proposition is negative or affirmative, but as either is an universal or particular affirmative, &c. Hence they dispose the several kinds of propositions into modes, and the syllogisms into figures, according as they affect the subject or the predicate. The modes are indicated by the letters, *a*, *e*, *i*. *o*, as they are affirmative or negative, universal or particular. There are nineteen modes and four figures. The first figure is when the middle term is the subject of the major, and the predicate of the minor: as,

No work of God is bad:
But the natural passions and appetites of men are the work of God;
Therefore they are not bad.

This figure includes four modes, denoted by the words, "Barbara, celarent, Darii, ferio;" referring to the vowels which each syllable contains.

10,000*l.* if the method determined the longitude to 1° of a great circle, or to 60 geographical miles; of 15,000*l.* if it determined it to 40 miles; and of 20,000*l.* if it determined it to 30 miles; with this proviso, that if any such method extend no further than 30 miles adjoining to the coast, the proposer should have no more than half the rewards. The act also appoints the first lord of the admiralty, the speaker of the house of commons, the first commissioner of trade, the admirals of the red, white, and blue squadrons, the master of the Trinity-house, the president of the royal society, the royal astronomer at Greenwich, the two Savilian professors at Oxford, and the Lucasian and Plumian professors at Cambridge, with several other persons, as commissioners for the longitude at sea. The Lowndian professor at Cambridge was afterwards added. After this act of parliament, several other acts passed in the reigns of George II. and III. for the encouragement of finding the longitude. At last, in 1774, an act passed, repealing all other acts, and offering separate rewards to any person who should discover the longitude, either by the watch keeping true time within certain limits, or by the lunar method, or by any other means. The act proposes as a reward for a timekeeper, the sum of 5000*l.* if it determine the longitude to 1° or 60 geographical miles; the sum of 7500*l.* if it determine it to 40 miles; and the sum of 10,000*l.* if it determine it to 30 miles, after proper trials specified in the act. If the method is by improved solar and lunar tables, constructed upon sir Isaac Newton's theory of gravitation, the author shall be entitled to 5000*l.* if such tables shall show the distance of the moon from the sun and stars, within fifteen seconds of a degree, answering to about seven minutes of longitude, after allowing half a degree for the errors of observation. And for any other method, the same rewards are offered as those for timekeepers, provided it gives the longitude true within the same limits, and is practicable at sea. The commissioners have also a power of giving smaller rewards, as they shall judge proper, to any one who shall make any discovery for finding the longitude at sea, though not within the above limits: provided, however, that if such person or persons shall afterwards make any further discovery as to come within the above-mentioned limits, such sum or sums as they may have received shall be considered as part of such greater reward, and deducted therefrom accordingly.

To find the longitude by a time-keeper. The sun appears to move round the earth from east to west, or to describe 360°, in 24 hours, and therefore he appears to move 15° in an hour. If therefore the meridians of two places make an angle of 15° with each other, or if the two places differ 15° in longitude, the sun will come to the eastern meridian one hour before he comes to the western meridian, and therefore when it is 12 o'clock at the former place, it is only eleven at the latter; and in general, the difference between the times by the clock at any two places, will be the difference of their longitudes, converted into time at the rate of 15° for an hour, the time at the eastern place being the forwardest. If, therefore, we can tell what o'clock it is at any two places at the same instant of time, we can find the difference of their longitudes, by allowing 15° for every hour that the clocks differ.

Let, therefore, the timekeeper be well regulated and set to the time of Greenwich, that being the place from which we reckon our longitude; then if the watch neither gains nor loses, it will always show the time at Greenwich, wherever you may be. Now to find the time by the clock at any other place, take the sun's altitude, and thence find the time; now the time thus found is apparent time, or that found by the sun, which differs from the time shown by the clock by the equation of time. We must, therefore, apply the equation of time to the time found by the sun, and we shall get the time by the clock; and the difference between the time by the clock so found, and the time by the timekeeper, or the time at Greenwich, converted into degrees at the rate of 15° for an hour, gives the longitude of the place from Greenwich. For example: let the time by the timekeeper, when the sun's altitude was taken, be 6h. 19′, and let the time deduced from the sun's altitude be 9h. 27′, and suppose at that time the equation of time to be 7′, showing how much the sun is that day behind the clock, then the time by the clock is 9h. 34′, the difference between which and 6h. 19′, is 3h. 15′; and this converted into degrees, at the rate of 15° for 1 hour, gives 48° 45′, the longitude of the place from Greenwich; and as the time is forwarder than that at Greenwich, the place lies to the east of Greenwich. Thus the longitude could be very easily determined, if you could depend upon the timekeeper. But as a watch will always gain or lose, before the timekeeper is sent out, its gaining or losing every day for some time, a month for instance, is observed; this is called the rate of going of the watch, and from thence the mean rate of going is thus found:

Suppose I examine the rate of a watch for 30 days; on some of those days I find it has gained, and on some it has lost; add together all the quantities it has gained, and suppose they amount to 17″; add together all the quantities it has lost, and suppose they amount to 13″; then upon the whole, it has gained 4″ in 30 days; and this is called the mean rate for that time; and this divided by 30, gives 0″,133 for the mean daily rate of gaining; so that if the watch had gained regularly 0″,133 every day, at the end of 30 days it would have gained just as much as it really did gain, by sometimes gaining and sometimes losing. Or you may get the mean daily rate thus: Take the difference between what the clock was too fast or too slow on the first and last days of observation, if it be too fast or too slow on each day; but take the sum, if it is too fast on one day and too slow on the other, and divide by the number of days between the observations, and you get the mean daily rate. Thus, if the watch was too fast on the first day 18″, and too fast on the last day 32″, the difference 14″ divided by 30, gives 0″,466, the mean daily rate of gaining. But if the watch was too fast on the first day 7″, and too slow on the last day 10″, the sum 17″ divided by 30, gives 0″,566, the mean daily rate of losing. After having thus got the mean daily rate of gaining or losing, and knowing how much the watch was too fast or too slow at first, you can tell, according to that rate of going, how much it is too fast or too slow at any other time. In the first case, for instance, let the watch have been 1′ 17″ too fast at first, and I want to know how much it is too fast 50 days after that time: now it gains 0″,133 every day; if this is multiplied by 50, it gives 7″,65 for the whole gain in 50 days; there-

fore, at the end of that time, the watch would be 1′. 23″,65 to fast. This would be the error, if the watch continued to gain at the above rate; and although, from the different temperatures of the air, and the imperfection of the workmanship, this cannot be expected, yet the probable error will by this means be diminished, and it is the best method we have to depend upon. In watches which are under trial at the Royal Observatory at Greenwich, as candidates for the rewards, this allowance of a mean rate is admitted, although it is not mentioned in the act of parliament: the commissioners, however, are so indulgent as to grant it, which is undoubtedly favourable to the watches.

As the rate of going of a watch is subject to vary from so many circumstances, the observer, whenever he goes ashore, and has sufficient time, should compare his watch for several days with the true time found by the sun, by which he will be able to find its rate of going. And when he comes to a place whose longitude is known, he may then set his watch to Greenwich time; for when the longitude of a place is known, you know the difference between the time there and at Greenwich. For instance, if he go to a place known to be 30° east longitude from Greenwich, his watch should be two hours slower than the time at that place. Find therefore the true time at that place, by the sun, and if the watch is two hours slower, it is right; if not, correct it by the difference, and it again gives Greenwich time.

In the year 1726, Mr. John Harrison produced a timekeeper of his own construction, which did not err above one second in a month for ten years together; and in the year 1736 he had a machine tried in a voyage to and from Lisbon, which was the means of correcting an error of almost a degree and a half in the computation of the ship's reckoning. In consequence of this success, Mr. Harrison received public encouragement to proceed, and he made three other time-keepers, each more accurate than the former, which were finished successively in the years 1739, 1758, and 1761; the last of which proved so much to his own satisfaction, that he applied to the commissioners of the longitude to have this instrument tried in a voyage to some port in the West Indies, according to the directions of the statute of the 12th of Anne above cited. Accordingly, Mr. William Harrison, son of the inventor, embarked in November 1761, on a voyage for Jamaica, with this fourth timekeeper or watch; and on his arrival there, the longitude, as shown by the timekeeper, differed but one geographical mile and a quarter from the true longitude, deduced from astronomical observations. The same gentleman returned to England with the timekeeper, in March 1762, when he found that it had erred in the four months, no more than 1′ 54″$\frac{1}{2}$ in time, or 28$\frac{5}{8}$ minutes of longitude; whereas the act requires no greater exactness than 30 geographical miles, or minutes of a great circle, in such a voyage. Mr. Harrison now claimed the whole reward of 20,000*l.* offered by the said act: but some doubts arising in the minds of the commissioners concerning the true situation of the island of Jamaica, and the manner in which the time at that place had been found, as well as at Portsmouth; and it being farther suggested by some, that although the timekeeper happened to be right at Jamaica, and after its return to England, it was by no means a proof that it had been always so in the intermediate time; another trial was therefore proposed, in a voyage to the island of Barbadoes, in which precautions were taken to obviate as many of these objections as possible. Accordingly the commissioners previously sent out proper persons to make astronomical observations on that island, which, when compared with other corresponding ones made in England, would determine, beyond a doubt, its true situation; and Mr. William Harrison again set out with his father's timekeeper, in March 1764, the watch having been compared with equal altitudes at Portsmouth before he set out, and he arrived at Barbadoes about the middle of May; where, on comparing it again by equal altitudes of the sun, it was found to show the difference of longitude between Portsmouth and Barbadoes to be 3h. 55m. 3s.; the true difference of longitude between these places, by astronomical observations, being 3h. 54m. 20.; so that the error of the watch was 43s., or 10′ 45″ of longitude. In consequence of this and the former trials, Mr. Harrison received one moiety of the reward offered by the 12th of queen Anne, after explaining the principles on which his watch was constructed, and delivering this, as well as the three former, to the commissioners of the longitude for the use of the public: and he was promised the other moiety of the reward, when other timekeepers should be made on the same principles, either by himself or others, performing equally well with that which he had last made. In the mean time, this last timekeeper was sent down to the Royal Observatory at Greenwich, to be tried there under the direction of the Rev. Dr. Maskelyne, the astronomer-royal. But it did not appear, during this trial, that the watch went with the regularity that was expected; from which it was apprehended that the performance even of the same watch was not at all times equal; and consequently that little certainty could be expected in the performance of different ones. Moreover the watch was now found to go faster than during the voyage to and from Barbadoes by 18 or 19 seconds in 24 hours; but this circumstance was accounted for by Mr. Harrison, who informs us that he had altered the rate of its going by trying some experiments, which he had not time to finish before he was ordered to deliver up the watch to the board. Soon after this trial, the commissioners of longitude agreed with Mr. Kendal, one of the watch-makers appointed by them to receive Mr. Harrison's discoveries, to make another watch on the same construction with this, to determine whether such watches could be made from the account which Mr. Harrison had given, by other persons as well as himself. The event proved the affirmative; for the watch produced by Mr. Kendal, in consequence of this agreement, went considerably better than Mr. Harrison's did. Mr. Kendal's watch was sent out with captain Cook, in his second voyage towards the south pole and round the globe, in the years 1772, 1773, 1774, and 1775; when the only fault found in the watch was, that its rate of going was continually accelerated; though in this trial of three years and a half it never amounted to 14″$\frac{1}{2}$ a day. The consequence was, that the house of commons, in 1774 to whom an appeal had been made, were pleased to order the second moiety of the reward to be given to Mr. Harrison, and to pass the act above-mentioned. Mr. Harrison had also at different times received some other sums of money,

as encouragements to him to continue his endeavours, from the board of longitude, and from the India company, as well as from many individuals. Mr. Arnold and some other persons have since also made several very good watches for the same purpose, and have been remunerated for their skill and labour.

Others have proposed various astronomical methods for finding the longitude. These methods chiefly depend on having an ephemeris or almanac suited to the meridian of some place, as Greenwich for instance, to which the Nautical Almanac is adapted, which shall contain for every day computations of the times of all remarkable celestial motions and appearances, as adapted to that meridian. So that if the hour and minute is known when any of the same phenomena are observed in any other place whose longitude is desired, the difference between this time and that to which the time of the said phenomenon was calculated and set down in the almanac, will be known, and consequently the difference of longitude also becomes known between that place and Greenwich, allowing at the rate of fifteen degrees to an hour.

Now it is easy to find the time at any place, by means of the altitude or azimuth of the sun or stars, which time it is necessary to find by such means, both in these astronomical modes of determining the longitude, and in the former by a timekeeper; and it is the difference between that time, so determined, and the time at Greenwich, known either by the timekeeper or by the astronomical observations of celestial phenomena, which gives the difference of longitude at the rate above-mentioned. Now the difficulty in these methods lies in the fewness of proper phenomena, capable of being thus observed; for all slow motions, such as belong to the planet Saturn, for instance, are quite excluded, as affording too small a difference, in a considerable space of time, to be properly observed; and it appears that there are no phenomena in the heavens proper for this purpose, except the eclipses or motions of Jupiter's satellites, and the eclipses or motions of the moon, viz. such as her distance from the sun or certain fixed stars lying near her path, or her longitude or place in the zodiac, &c. Now of these methods,

1st. That by the eclipses of the moon is very easy, and sufficiently accurate, if they did but happen often, as every night. For at the moment when the beginning or middle or end of an eclipse is observed by a telescope, there is no more to be done but to determine the time by observing the altitude or azimuth of some known star; which time being compared with that in the tables, set down for the happening of the same phenomenon at Greenwich, gives the difference in time, and consequently of longitude sought. But as the beginning or end of an eclipse of the moon cannot generally be observed nearer than one minute, and sometimes two or three minutes of time, the longitude cannot certainly be determined by this method, from a single observation, nearer than one degree of longitude. However, by two or more observations, as of the beginning and end, &c. a much greater degree of exactness may be attained.

2d. The moon's place in the zodiac is a phenomenon more frequent than her eclipses; but then the observation of it is difficult, and the calculus perplexed and intricate, by reason of two parallaxes; so that it is hardly practicable to any tolerable degree of accuracy.

3d. But the moon's distances from the sun or certain fixed stars, are phenomena to be observed many times in almost every night, and afford a good practical method of determining the longitude of a ship at almost any time; either by computing from thence the moon's true place, to compare with the same in the almanac; or by comparing her observed distance itself with the same as there set down.

From the great improvements made by Newton in the theory of the moon, and more lately by Euler and others on his principles, professor Mayer, of Gottingen, was enabled to calculate lunar tables more correct than any former ones; having so far succeeded as to give the moon's place within one minute of the truth, as has been proved by a comparison of the tables with the observations made at the Greenwich observatory by Dr. Bradley, and by Dr. Maskelyne, the late astronomer-royal; and the same have been still farther improved under his direction, by the late Mr. Charles Mason, by several new equations, and the whole computed to tenths of a second. These tables, when compared with the above-mentioned series of observations, a proper allowance being made for the unavoidable error of observation, seem to give always the moon's longitude in the heavens correctly within 30 seconds of a degree; which greatest error, added to a possible error of one minute in taking the moon's distance from the sun or a star at sea, will at a medium only produce an error of 42 minutes of longitude. To facilitate the use of the tables, Dr. Maskelyne proposed a nautical ephemeris, the scheme of which was adopted by the commissioners of longitude, and first executed in the year 1767, since which time it has been regularly continued. But as the rules that were given in the appendix to one of those publications, for correcting the effects of refraction and parallax, were thought too difficult for general use, they have been reduced to tables. So that, by the help of the ephemeris, these tables, and others that are also provided by the board of longitude, the calculations relating to the longitude, which could not be performed by the most expert mathematician in less than four hours, may now be completed with great ease and accuracy in half an hour.

As this method of determining the longitude depends on the use of the tables annually published for this purpose, those who wish for farther information are referred to the instructions that accompany them, and particularly to those that are annexed to the tables requisite to be used with the Astronomical and Nautical Ephemeris.

4th. The phenomena of Jupiter's satellites have commonly been preferred to those of the moon, for finding the longitude; because they are less liable to parallaxes than these are, and besides they afford a very commodious observation whenever the planet is above the horizon. Their motion is very swift, and must be calculated for every hour.

Now, to find the longitude by these satellites: with a good telescope observe some of their phenomena, as the conjunction of two of them, or of one of them with Jupiter, &c. and at the same time find the hour and minute, from the altitudes of the stars, or by means of a clock or watch, previously regulated for the place of observation; then, consulting tables of the satellites, observe the time when the same appearance happens in the meridian of the

place for which the tables are calculated; and the difference of time, as before, will give the longitude.

The eclipses of the first and second of Jupiter's satellites are the most proper for this purpose; and as they happen almost daily, they afford a ready means of determining the longitude of places at land, having indeed contributed much to the modern improvements in geography; and if it were possible to observe them with proper telescopes, in a ship under sail, they would be of great service in ascertaining its longitude from time to time. To obviate the inconvenience to which these observations are liable from the motions of the ship, Mr. Irwin invented what he called a marine chair: this was tried by Dr. Maskelyne, in his voyage to Barbadoes, when it was found that no benefit could be derived from the use of it. And indeed, considering the great power requisite in a telescope proper for these observations, and the violence as well as irregularities in the motion of a ship, it is to be feared that the complete management of a telescope on shipboard will always remain among the desiderata in this part of nautical science. And farther, since all methods that depend on the phenomena of the heavens, have also this other defect, that they cannot be observed at all times, this renders the improvement of timekeepers of the greater importance.

LONICERA, *honeysuckle*, a genus of the monogynia order, in the pentandria class of plants. The corolla is monopetalous and irregular; the berry polyspermous, bilocular, and inferior. There are 19 species, of which the most remarkable are,

1. The alpigena, or upright red-berried honeysuckle, rises with a shrubby, short, upright stem, four or five feet high.

2. The cærulea, or blue-berried honeysuckle, with a shrubby upright stem, three or four feet high, and many white flowers proceeding from the sides of the branches.

3. The nigra, or black-berried upright honeysuckle, with a shrubby stem three or four feet high, and white flowers succeeded by single and distinct black berries.

4. The tartarica, or Tartarian honeysuckle, with a shrubby upright stem, three or four feet high, heart-shaped opposite leaves, and whitish erect flowers succeeded by red berries, sometimes distinct, and sometimes double.

5. The diervilla, or yellow-flowered Arcadian honeysuckle, with shrubby upright stalks, to the height of three or four feet, and clusters of pale yellow flowers, appearing in May and June, and sometimes continuing till autumn.

4. The xylosteum, or fly honeysuckle, with a strong shrubby stem, branching erect to the height of seven or eight feet, and erect white flowers proceeding from the sides of the branches.

7. The symphoricarpos, or shrubby St. Peter's-wort, with a shrubby rough stem, four or five feet high, and small greenish flowers.

8. The periclymenum, or common climbing honeysuckle, has two principal varieties, viz. the English wild honeysuckle, or woodbine of the woods and hedges, and the Dutch or German honeysuckle, with a shrubby declinated stalk, and long trailing purplish branches, furnishing large beautiful red flowers of a fragrant odour, appearing in June and July.

9. The caprifolium, or Italian honeysuckle, with shrubby declinated stalks, sending out long slender trailing branches, terminated by verticillate or whorled bunches of close-sitting flowers, very fragrant, and white, red, and yellow colours.

10. The sempervirens, or evergreen trumpet-flowered honeysuckle, with a shrubby declinated stalk, sending out long slender trailing branches, terminated by naked verticillate spikes, of long, unreflexed, deep-scarlet flowers, very beautiful, but of little fragrance.

LOOF, in the sea language, is a term used in various senses; thus the loof of a ship is that part of her aloft which lies just before the chest-trees; hence the guns which lie there are called loof-pieces: keep your loof, signifies, keep the ship near to the wind: to loof into a harbour, is to sail into it close by the wind: loof up, is to keep nearer the wind: to spring the loof, is when a ship that was going large before the wind, is brought close by the wind.

Loof-tackle, is a tackle in a ship which serves to lift goods of small weight in or out of her.

LOOKING-GLASSES. See Optics.

LOOM, the weaver's frame, a machine whereby several distinct threads are woven into one piece. Looms are of various structures, accommodated to the various kinds of materials to be woven, and the various manner of weaving them, viz. for woollens, silks, linens, cottons, cloths of gold, and other works, as tapestry, ribands, stockings, &c. See Weaving.

The weaver's loom-engine, otherwise called the Dutch loom-engine, was brought into use from Holland to London, in or about the year 1676.

The lower compartment of Plate LXXIX. Lock and Loom, represents a loom for weaving silks or other plain work. A, fig. 6, is a roll called the cloth-beam, on which the cloth is wound as it is wove; at one end it has a racket-wheel *a*, and a click to prevent its running back; at the same end it has also four holes in it, and is turned by putting a stick in these holes: at the other end of the loom is another roll B, on which the yarn is wound; this has two small cords *bb* wrapped round it, the ends of which are attached to a bar *d*, which has a weight D hung to it; by this means a friction is caused, which prevents the roll B turning by accident. EF are called lambs; they are composed of two sticks *efki*, between which are fastened a great number of threads; to the bar *e* are fastened two cords *gh*, which pass over pulleys, and are fastened to the bar *h* of the lamb F; the lower bars of each lamb are connected by cords with the treadles GH; the workman sits on the seat K, and places his feet upon these treadles; as they are connected together by the cords *gh*, when he presses down one, it will raise the other, and the lambs with them; a great number of threads, according to the width of the cloth, are wound round the yarn-beam B, and are stretched to the cloth-beam A; the middle of the threads which compose the lamb EF, have loops (called eyes) in them, through which the threads between the rolls AB, which are called the warp, are passed; the first thread of the warp goes through the loops of the lambs E, the next attached to the lamb F, and so on alternately; by this means, when the weaver presses down one of the treadles with his foot and raises the other, one lamb draws up every other thread,

and the other sinks all the rest, so as to make an opening between the sets of thread: LL is a frame moving on a centre at the top of the frame of the loom; the lower part of this frame is shown in fig. 8; LL are the two uprights of the frame, *l* is the bar that connects them, M is a frame carrying a great number of pieces of split reed or sometimes fine wire at equal distances; between these the threads of the warp are passed; the frame M is supported by a piece of wood *m* called the shuttle-race, which is fastened into the front of the pieces LL; each end of this piece has boards nailed to the sides, so as to form troughs NO; at a small distance above these are fixed two very smooth wires *no;* their use is to guide the two pieces *pq*, called peckers or drivers; to each of these pieces a string is fastened, and these strings are tied to a piece of wood P, which the weaver holds in his hand, and by snatching the stick to either side, draws the pecker forwards very quick, and gives the shuttle, fig. 7. (which is to be laid in the trough before the pecker) a smart blow, and drives it along across the race *m* into the other trough, where it pushes the pecker along to the end of the wire, ready for the next stroke which throws it back again, and so on. Fig. 7. represents the under side of the shuttle on a larger scale; its ends are pointed with iron; it has a large mortise through the middle of it, in which is placed a quill *a* containing the yarn; *b* is a piece of glass, called the eye of the shuttle, with a hole in it, through which comes the end of the thread; *dd* are two small wheels to make it run easily on the race. The operations are as follow: the workman sitting upon the seat K. holds the stick P in his right hand, and takes hold of one of the bars of the frame LL with his left; presses his foot on one of the treadles GH, which by means of the lambs EF, as before described, divides the warp; he then snatches the stick P, and by that means throws the shuttle, fig. 7, which unwinds the thread in it, and leaves it lying in between the threads of the warp; he then relieves the treadle he before kept down, and presses down the other; while he is doing this, he with his left hand draws the frame LL towards him, and then returns it. The use of this is to beat the last thread thrown by the shuttle close up to the one that was thrown before it by the split reeds M, fig. 8. As soon as he has brought the frame LL back to its original position, and again divided the warp by the treadle, he throws the shuttle again: when he has in this manner finished about 12 or 14 inches of cloth, he winds it up by turning the roll A with the stick, as before described. Some very expert weavers will throw the shuttle and perform the other operations at the rate of 120 times per minute.

Loom, in the sea language. When a ship appears big when seen at a distance, they say she looms.

Loom gale, a gentle easy gale of wind, in which a ship can carry her topsails atrip.

LOOP, in the iron works, denotes a part of a sow or block of cast iron, broken or melted off from the rest.

LOPHIUS, *fishing-frog, toad-fish,* or *sea-devil,* a genus of the branchiostegious order of fishes, whose head is in size equal to all the rest of the body. There are three species, the most remarkable of which is the piscatorius, or common fishing-frog, an inhabitant of the British seas. This singular fish grows to a large size, some being between four and five feet in length; and Mr. Pennant mentions one taken near Scarborough, whose mouth was a yard wide. The fishermen on that coast have a great regard for this fish, from a supposition that it is a great enemy to the dog-fish; and whenever they take it with their lines, set it at liberty. The head of this fish is much larger than the whole body, is round at the circumference, and flat above; the mouth of a prodigious wideness. The under jaw is much longer than the upper; the jaws are full of slender sharp teeth; in the roof of the mouth are two or three rows of the same. On each side the upper jaw are two sharp spines, and others are scattered about the upper part of the head. The body grows slender near the tail, the end of which is quite even. The colour of the upper part of this fish is dusky; the lower part white; the skin smooth.

LORANTHUS, a genus of the monogynia order, in the hexandria class of plants, and in the natural method ranking under the 48th order, aggregatæ. The germen is inferior; there is no calyx; the corolla is sexfid and revoluted; the stamina are at the tops of the petals; the berry is monospermous. There are 18 species, natives of America.

LORD. See Peer.

LORD'S DAY. No person upon the Lord's day shall serve or execute any writ, process, warrant, order, judgment, or decree (except in cases of treason, felony, or breach of the peace) but the service thereof shall be void.

LOTTERIES are declared to be public nuisances, 5 Geo. I. c. 9.; but for the public service of the government, lotteries are frequently established by particular statutes, and managed by special officers and persons appointed.

By stat. 42 Geo. III. c. 54, lottery-office keepers are to pay 50*l*. for every licence in London, Edinburgh, and Dublin, or within 20 miles of either, and 10*l*. for every licence for every other office; and licensed persons shall deposit 30 tickets with the receiver general of the stamp-duties, or licence to be void.

By stat. 22 Geo. III. c. 47, lottery-office keepers must take out a licence; and offices are to be open only from eight in the morning to eight in the evening, except the Saturday evening preceding the drawing. The sale of chances and shares of tickets, by persons not being proprietors thereof, is prohibited under penalty of 50*l*.; and by 42 Geo. III. c. 119, all games or lotteries called *little goes*, are declared public nuisances, and all persons keeping any office or places for any game or lottery, not authorized by law, shall forfeit 500*l*. and be deemed rogues and vagabonds. The proprietor of a whole ticket may nevertheless insure it for its value only, with any licensed office for the whole time of drawing from the time of insurance, under a bona fide agreement without a stamp.

LOTUS, or *bird's-foot trefoil,* a genus of the decandria order, in the diadelphia class of plants, and in the natural method ranking under the 32d order, papilionaceæ. The legumen is cylindrical, and very erect, the alæ closing upwards longitudinally; the calyx is tubulated. There are 23 species, but only five or six are usually cultivated in our gardens.

1. The siliquosus, or winged pea, has trailing, slender, branchy stalks, about a foot long, with trifoliate oval leaves, and from the axillas of the branches, large, papilionaceous, red flowers, one on each footstalk, suc-

ceeded by tetragonous solitary pods, having a membranous wing or lobe, running longitudinally at each corner. It flowers in June and July, and the seeds ripen in autumn. 2. The creticus, or Cretan silvery lotus. 3. The Jacobæus, or black lotus of St. James's island. 4. The hirsutus, or hairy Italian lotus. 5. The dorcynium, white Austrian lotus, or shrub trefoil of Montpelier. 6. The edulis, with yellow flowers.

The first species is a hardy annual. The other species may be propagated either by seeds or cuttings, but require to be kept in pots in the greenhouse during the winter season.

LOUIS, or Knights of St. Louis, the name of a military order in France, instituted by Louis XIV. in 1693.

LOUSE. See Pediculus.

LOXIA, a genus of birds of the order of passeres, the distinguishing characters of which are: the bill is strong, convex above and below, and very thick at the base; the nostrils are small and round; the tongue is as if cut off at the end; the toes are four, placed three before and one behind, excepting one species; which has only two toes before and one behind. The most remarkable are:

1. The curvirostra, or common cross-bill, is about the size of a lark, is known by the singularity of its bill, both mandibles of which curve opposite ways and cross each other: the general colour of the plumage in the male is of a red-lead, inclining to rose-colour, and more or less mixed with brown; the wings and tail are brown; the legs black. The female is of a green colour, more or less mixed with brown in those parts where the male is red. This species is a constant inhabitant of Sweden, Germany, Poland, Switzerland, Russia, and Siberia, where it breeds; but migrates sometimes in vast flocks into other countries, as is now and then the case in respect to England; for though in some years a few are met with, yet in others it has been known to visit there by thousands, fixing on such spots as are planted with pines, for the sake of the seeds, which are its natural food: it is observed to hold the cone in one claw like the parrot, and to have all the actions of that bird when kept in a cage. It is also found in North America and Greenland; and is said to make its nest in the highest parts of the fir-trees, fastening it to the branch with the resinous matter which exudes from the trees.

2. The coccothraustes, or hawfinch, is in length seven inches. This species is ranked among the British birds; but only visits those kingdoms occasionally, and for the most part in winter, and is never known to breed there. It is more plenty in France. It feeds on berries, kernels, &c. and from the great strength of the bill, it cracks the stones of the fruit of the haws, cherries, &c. with the greatest ease.

3. The pyrrhula, or bulfinch, is so generally known as almost to supercede description. This species is common in most parts of the continent of Europe, and throughout Russia and Siberia, at which last places it is caught for the table. In winter it approaches gardens and orchards, and has been generally stigmatised for making havock among the buds of trees. From some late observations however, it would appear, that the object of these birds is not the bud, but "the worm in the bud;" and that this species, in conjunction with various other species of small birds, are the frequent means of defending the embryo fruits, and thence promoting their growth to maturity; for the warmth that swells the buds, not only hatches eggs of unnumbered tribes of insects, whose parent flies, by an unerring instinct, laid them there, but brings forward a numerous race already in a caterpillar state, that now issue from their concealments, and make their excursion along the budding branches, and would probably destroy every hope of fruitage, but for those useful instruments for its preservation, whose young are principally fed by eating caterpillars. The bulfinch, in its wild state, has only a plain note; but when tamed, it becomes remarkably docile, and may be taught any tune after a pipe, or to whistle any note in the best manner; it seldom forgets what it has learned; and will become so tame as to come at call, perch on its master's shoulder, and (at command) go through a difficult musical lesson. They may be also taught to speak, and some thus instructed are annually brought to London from Germany.

4. The cardinalis, or cardinal grossbeak, near eight inches in length. The bill stout, and of a pale-red colour; the irides a hazel; the head is greatly crested, the feathers rising up to a point when erect; round the bill, and on the throat, the colour is black, the rest of the bird of a fire-red. The female differs from the male, being mostly of a reddish brown. This species is met with in several parts of North America, and has attained the name of Virginia nightingale, from the fineness of its song, the note of which resembles that of the nightingale.

5. The orix, or grenadier grossbeak, is about the size of a house-sparrow. The forehead, sides of the head, and chin, are black, the breast and belly the same; the wings are brown, with pale edges; and the rest of the body of a beautiful red colour. These birds are inhabitants of St. Helena; they are also in plenty at the Cape of Good Hope, where they frequent watery places that abound with reeds, and among which they are supposed to make their nest. If, as is supposed, this is the same with Kolben's finch, he says that the nest is of a peculiar contrivance, made with small twigs, interwoven very closely and tightly with cotton, and divided into two apartments with but one entrance, the upper for the male, the lower for the female, and is so tight as not to be penetrated by any weather. He adds, that the bird is scarlet only in summer, being in the winter wholly ash-coloured. These birds, seen among the green reeds, are said to have a wonderful effect: for, from the brightness of their colours, they appear like so many scarlet lilies. See Plate LXXXIV. Nat. Hist. fig. 253.

6. The pensilis, or pensile grossbeak, (the toddy-bird of Fryer) is about the size of the house-sparrow: the bill is black; the irides are yellow; the head, throat, and forepart of the neck, the same; from the nostrils springs a dull green stripe, which passes through the eye and beyond it, where it is broader; the hind part of the head and neck, the back, rump, and wing-coverts, are of the same colour; the quills are black, edged with green; the belly is deep grey, and the vent of a rufous red; the tail and legs are black. This species is found at Madagascar; and fabricates a nest of a curious construction, composed of straw and reeds interwoven in shape of a bag, the opening beneath. It is fastened above to a twig of

some tree; mostly to those growing on the borders of streams. On one side of this, within, is the true nest. The bird does not form a new nest every year, but fastens a new one to the end of the last; and often as far as five in number, one hanging from another. These build in society like rooks, often five or six hundred being seen on one tree. They have three young at each hatch. See Plate LXXXIV. Nat. Hist. fig. 254.

7. The bengalensis, or Bengal grossbeak, is a trifle bigger than a house-sparrow. The female lays three or four eggs.

8. The socia, or sociable grossbeak, is about the size of a bullfinch; the general colour of the body above is a rufous brown, the under parts yellowish. It inhabits the interior country at the Cape of Good Hope, where it was discovered by colonel Paterson. These birds, according to our author, live together in large societies, and their mode of nidification is extremely uncommon. They build in a species of mimosa which grows to an uncommon size. In one described by col. Paterson, there could be no less a number than from 800 to 1000 residing under the same roof. He calls it a roof, because it perfectly resembles that of a thatched house; and the ridge forms an angle so acute and so smooth, projecting over the entrance of the nest below, that it is impossible for any reptile to approach them. The industry of these birds " seems almost equal (says our author) to that of the bee: throughout the day they appear to be busily employed in carrying a fine species of grass, which is the principal material they employ for the purpose of erecting this extraordinary work, as well as for additions and repairs. Though my short stay in the country was not sufficient to satisfy me by ocular proofs, that they added to their nest as they annually increased in numbers, still from the many trees which I have seen borne down with the weight, and others which I have observed with their boughs completely covered over, it would appear that this is really the case. When the tree which is the support of this aerial city is obliged to give way to the increase of weight, it is obvious that they are no longer protected, and are under the necessity of rebuilding in other trees. One of these deserted nests I had the curiosity to break down, so as to inform myself of the internal structure of it, and found it equally ingenious with that of the external. There are many entrances, each of which forms a regular street, with nests on both sides, at about two inches distant from each other.

9. The tridactyla, or three-toed grossbeak, (the guifso balito of Buffon) has only three toes, two before and one behind. The bill is toothed on the edges; the head, throat, and fore-part of the neck, are of a beautiful red; the upper part of the neck, back, and tail, are black; the wing-coverts brown, edged with white; quills brown, with greenish edges; and legs a dull red; the wings reach half-way on the tail. This species inhabits Abyssinia, where it frequents woods, and is a solitary species.

According to Linnæus there are 48 species of the loxia.

LOZENGE, Lozange, *rhombus*, in geometry, a quadrilateral figure, consisting of four equal and parallel sides, two of whose opposite angles are acute, and the other two obtuse; the distance between the two obtuse ones being always equal to the length of one side: when the sides are unequal, this figure is called a rhomboides.

Lozenge, in heraldry, a rhombus, or figure of equal sides, but unequal angles.

Lozenge, in pharmacy, the same with what is otherwise called troche.

LUCANUS, *stag-chaffer*, a genus of insects of the order coleoptera: the generic character is, antennæ clavated, with compressed tip, divided into lamellæ on the inner side; jaws stretched forwards, exserted, and toothed. The principal species is the lucanus cervus, commonly known by the name of the stag-beetle, or stag-chaffer. It is the largest of all the European coleopterous insects, sometimes measuring nearly two inches and a half in length, from the tips of the jaws to the end of the body. Its general colour is a deep chesnut, with the thorax and head, which is of a squarish form, of a blacker cast; and the jaws are often of a brighter or redder chesnut-colour than the wings-shells; the legs and under-parts are coal-black, and the wings, which, except during flight, are concealed under the shells, are large, and of a fine pale yellowish-brown. This remarkable insect is chiefly found in the neighbourhood of oak-trees, delighting in the sweet exsudation or honey-dew so frequently observed on the leaves. Its larva, which perfectly resembles that of the genuine beetles, is also found in the hollows of oak-trees, residing in the fine vegetable mould usually seen in such cavities, and feeding on the softer parts of the decayed wood. It is of very considerable size, of a pale yellowish or whitish-brown colour; and when stretched out at full length, measures nearly four inches. When arrived at its full size, which, according to some, is hardly sooner than the fifth or sixth year, it forms, by frequently turning itself, and moistening it with its glutinous saliva, a smooth oval hollow in the earth, in which it lies, and afterwards remaining perfectly still for the space of near a month, divests itself of its skin, and commences pupa or chrysalis. It is now of a shorter form than before, of a rather deeper colour, and exhibits in a striking manner the rudiments of the large extended jaws and broad head so conspicuous in the perfect insect: the legs are also proportionally larger and longer than in the larva state. The ball of earth in which this chrysalis is contained is considerably larger than a hen's egg, and of a rough exterior surface, but perfectly smooth and polished within. The chrysalis lies about three months before it gives birth to the complete insect, which usually emerges in the months of July and August. The time, however, of this insect's growth and appearance in all its states varies much, according to the difference of seasons. It is not very uncommon in many parts of England.

The commonly supposed female differs so much in appearance from the male, that it has by some authors been considered as a dictinct species. It is not only smaller than the former, but totally destitute of the long and large ramified jaws, instead of which it has a pair of very short curved ones, slightly denticulated on their inner side: the head is also of considerably smaller diameter than the thorax. In point of colour it resembles the former.

The exotic species of this genus are mostly natives of America, and one in particular, frequently found in Virginia, is so nearly allied to the English stag-beetle as

hardly to differ, except in having fewer denticulations or divisions on the jaws.

A highly elegant species has lately been discovered in New Holland. This differs from the rest in being entirely of a beautiful golden-green colour, with short, sharp-pointed, denticulated jaws of a brilliant copper-colour. The whole length of the insect is rather more than an inch. There are seven species of the lucanus.

LUCIDA, in astronomy, an appellation given to several fixed stars on account of their superior brightness; as the lucida coronæ, a star of the second magnitude in the northern crown; the lucida hydræ; or cor hydræ; and the lucida lyræ, a star of the first magnitude in that constellation.

LUDWIGIA, a genus of the monogynia order, in the tetrandria class of plants, and in the natural method ranking under the 17th order, calycanthemæ. The corolla is tetrapetalous; the calyx quadripartite, superior; the capsule tetragonal quadrilocular, inferior, and polyspermous. There are four species, annuals of the West Indies.

LUES. See MEDICINE.

LUMBAGO. See MEDICINE.

LUMBRICUS, the *worm*, in zoology; a genus of insects belonging to the order of vermes intestina. The body is cylindrical, annulated, with an elevated belt near the middle, and a vent-hole on its side. There are two species of this animal: 1. Lumbricus terrestris, the earth or dew worm, Mr. Barbut observes, differs extremely in colour and external appearance in the different periods of its growth, which has occasioned people little acquainted with the variations of this kind of animals to make four or five different species of them. The general colour is a dusky red. They live under ground. never quitting the earth but after heavy rains, or at the approach of storms. The method to force them out is, either to water the ground with infusions of bitter plants, or to trample on it. The bare motion on the surface of the soil drives them up, in fear of being surprised by their formidable enemy, the mole. The winding progression of the worm is facilitated by the inequalities of its body, armed with small, stiff, sharp-pointed bristles: when it means to insinuate itself into the earth, there oozes from its body a clammy liquor, by means of which it slides down. It never damages the roots of vegetables. Its food is a small portion of earth, which it has the faculty of digesting. The superfluity is ejected by way of excrement, under a vermicular appearance. Earth-worms are hermaphrodites. 2. The marinus, marine worm, or lug, (see Plate LXXXIV. Nat. Hist. fig. 255.) is of a pale red colour, and the body is composed of a number of annular joints; the skin is scabrous, and all the rings or joints are covered with little prominences, which render it extremely rough to the touch. It is an inhabitant of the mud about the sea-shores, and serves for food to many kinds of fish. The fishermen bait their hooks and nets with it.

LUNAR CAUSTIC. } See SILVER, CHEMISTRY, and
LUNA CORNEA. } SALTS, *Detonating*.

LUNARIA, SATIN-FLOWER, MOONWORT, or HONESTY, a genus of the siliculosa order, in the tetradynamia class of plants, and in the natural method ranking under the 39th order, siliquosæ. The silicula is entire, elliptical, compressed-plane, and pedicellated; with the valves equal to the partition, parallel, and plane; the leaves of the calyx are alternately fritted at the base. There are three species. This plant is famous in some parts of England for its medicinal virtues, though it has not the fortune to be received in the shops. The people in the northern countries dry the whole plant in an oven, and give as much as will lie on a shilling for a dose twice a day in hemorrhages of all kinds, and with great success. The Welch, among whom it is not uncommon, Dr. Needham informs us, make an ointment of it, which they use externally, and pretend it cures dysenteries.

LUNATIC. See IDEOT.

LUNGS. See ANATOMY, and PHYSIOLOGY.

LUPINUS, *lupin*, a genus of the decandria order, in the diadelphia class of plants, and in the natural method ranking under the 32d order, papilionaceæ. The calyx is bilabiated; there are five oblong and five roundish antheræ; the legumen is coriaceous. There are ten species, chiefly hardy herbaceous flowery annuals, rising with upright stalks from one to three or four feet high, ornamented with digitate or fingered leaves, and terminated by long whorled spikes of papilionaceous flowers, white, blue, yellow, and rose-coloured. They are all easily raised from seed, and succeed in any open borders, where they make a fine variety.

LUPUS, in astronomy, a southern constellation, consisting of 19, or, according to Flamsteed, of 24 stars.

LUSTRATION, in antiquity, sacrifices or ceremonies by which the ancients purified their cities, field, armies, or people, defiled by any crime or impurity.

LUSTRE, a term signifying the gloss or brightness which appears on the external surface of a mineral, or on the internal surface when newly broken. The first is called the external, the second internal lustre. Two particulars respecting lustre require attention, viz. the degree, and the kind.

1. With respect to degree, Dr. Thomson gives five terms of comparison, viz. 1. very brilliant; 2. brilliant; 3. sub-brilliant; 4. glimmering, that is, having only certain parts brilliant; 5. dull, or without lustre.

2. With respect to kind, the lustre is either metallic or common. The common lustre is subdivided into vitreous or glossy, silky, waxy or greasy, mother of pearl, diamond, and semi-metallic.

LUTE, a stringed instrument formerly much in use; anciently containing only five rows of strings, but to which six, or more, were afterwards added. The lute consists of four parts, viz. the table; the body, which has nine or ten sides; the neck, which has as many stops or divisions; and the head, or cross, in which screws for tuning it are inserted. In playing this instrument, the performer strikes the strings with the fingers of the right hand, and regulates the sounds with those of the left hand. The origin of this instrument is not known, though generally believed to be of very early date. Indeed, authors are not agreed as to the country to which we are indebted for its invention. Some give it to Germany, and derive its name from the German word lutue, which signifies the same thing, while others ascribe it to the Arabians, and trace its name from the Arabic alland.

LUTES. In many chemical operations the vessels must

be covered with something to preserve them from the violence of the fire, from being broken or melted; and also to close exactly their joinings to each other, in order to retain the substances which they contain, when they are volatile, and reduced to vapour.

The coating used for retorts, &c. to defend them from the action of the fire, is usually composed of nearly equal parts of coarse sand, and refractory clay. These matters ought to be well mixed with water and a little hair, so as to form a liquid paste, with which the vessels are covered, layer upon layer, till it is of the required thickness. The sand mixed with the clay is necessary to prevent the cracks which are occasioned by the contracting of the clay during its drying, which it always does when pure. The hair serves also to bind the parts of the lute, and to keep it applied to the vessel; for, notwithstanding the sand which is introduced into it, some cracks are always formed, which would occasion pieces of it to fall off.

The lutes with which the joinings of vessels are closed, are of different kinds, according to the nature of the intended operations, and of the substances to be distilled in these vessels.

When vapours of watery liquors, and such as are not corrosive, are to be contained, it is sufficient to surround the joining of the receiver, to the nose of the alembic, or of the retort, with slips of paper or linen, covered with flour paste. In such cases also, slips of wet bladder are very conveniently used.

When more penetrating and dissolving vapours are to be contained, a lute is to be employed of quick-lime, slacked in air, and beaten into a liquid paste with whites of eggs. This paste is to be spread upon linen slips, which are to be applied exactly to the joining of the vessel. This lute is very convenient, easily dries, becomes solid, and sufficiently firm.

Lastly, when saline, acid, and corrosive vapours are to be contained, we must then have recourse to the lute called fat-lute. This lute is made by forming into a paste some dried clay finely powdered, sifted through a silken searce, and moistened with water; and then, by beating this paste well in a mortar with boiled linseed-oil, that is, oil which has been rendered dry by litharge dissolved in it, this lute easily takes and retains the form given to it. It is generally rolled into cylinders of a convenient size. These are to be applied. by flattening them, to the joinings of the vessels, which ought to be perfectly dry; because the least moisture would prevent the lute from adhering. When the joinings are closed with this fat-lute, the whole is to be covered with slips of linen spread with a lute of lime and whites of eggs. These slips are to be fastened with pack-thread. The second lute is necessary to keep on the fat-lute, because the latter remains soft, and does not become solid enough to stick on alone.

Ground linseed made into a paste with water makes also a very useful lute for most occasions.

LUTHERANS, the christians who follow the opinions of Martin Luther, one of the principal reformers of the church in the sixteenth century. See Gregory's Church History, vol. ii.

LUXATION. See SURGERY.

LYCHNIS, *campion*, a genus of the pentagynia order, in the pentandria class of plants, and in the natural method ranking under the 22d order, caryophylleæ. The calyx is monophyllous, oblong, and smooth; there are five unguiculated petals, with the segments of the limbs almost bifid; the capsule quinquelocular. There are 12 species, the principal are, 1. The chalcedonica, or chalcedonian scarlet. Of this there are varieties, with single scarlet flowers, with large double scarlet flowers of exceeding beauty and elegance, with pale red flowers, and with white flowers. Of these varieties the double scarlet lychnis is superior to all for size and elegance, the flowers being large, very double, and collected into a very large bunch, exhibit a charming appearance; the single scarlet kind is also very pretty, and the others effect an agreeable variety with the scarlet kinds. 2. The diurna: the varieties are, the common single red-flowered bachelor's button, double red, double white, and single white-flowered. The double varieties are exceeding ornamental in their bloom; the flower large, very double, and continue long in blow; the single red sort grows wild by ditch-sides and other moist places in many parts of England; from which the doubles were accidentally obtained by culture in gardens. 3. The viscaria, or viscous German lychnis, commonly called catch-fly. Of this also there are varieties with single red flowers, with double red flowers, and with white flowers. The double variety is considerably the most eligible for general culture, and is propagated in plenty by parting the roots. All the varieties of this species emitting a glutinous liquid matter from their stalks, flies happening to light on them sometimes stick and entangle themselves, whence the plant obtains the name catch-fly. 4. The flos cuculi, cuckoo-flower lychnis. The flowers having each petal deeply quadrifid in a torn or ragged-like manner, the plant obtained the name of ragged robin. There are varieties with single and double flowers. The double sort is a large flower; it is an improved variety of the single, which grows wild in most of our moist meadows, and is rarely cultivated; but the double, being very ornamental, merits culture in every garden.

LYCIUM, a genus of the monogynia order, in the pentandria class of plants, and in the natural method ranking under the 28th order, luridæ. The corolla is tubular, having its throat closed up with the beard of the filaments; the berry is bilocular. There are eight species, natives of various countries, and chiefly shrubs.

LYCOPERDON, a genus of the natural order of fungi, belonging to the cryptogamia class of plants. The fungus is roundish, and full of farinaceous seeds. Dr. Withering reckons 25 species, of which the following are the most remarkable: 1. The tuber, truffles, or subterraneous puff-balls, is a native of woods both in England and Scotland. It is a subterraneous fungus, growing generally in clusters 3 or 4 inches under ground, without any visible root. The figure of it is nearly spherical, the size that of a potatoe; the exterior coat at first white, afterwards black, and studded with pyramidical or polyhedrous tubercles; the internal substance solid and callous, of a dirty-white or pale-brown colour, grained like a nutmeg with serpentine lines; in which, according to Micheli, are imbedded minute oval capsules, containing each from 2 to 4 round watered seeds. The truffles of Great Britain seldom exceed 3 or 4 ounces in weight; but in Italy, and some other parts of the continent, they

are said to have been found of the enormous size of 8, and even 14 pounds. They have a volatile and somewhat urinous smell, and are reputed to be aphrodisical. 2. The bovista, or common puff-ball, is frequent in meadows and pastures in the autumn. It varies exceedingly in size, figure, superfices, and colour. In general, it consists of a sack or bag, having a root at its base, and the bag composed of 3 membranes, an epidermis, a tough white skin, and an interior coat which adheres closely to the central pith. The pith in the young plants is of a yellowish colour, at first firm and solid, but soon changes into a cellular spongy substance, full of a dark dull-green powder, which discharges itself through an aperture at the top of the fungus, which aperture is formed of lacerated segments, in some varieties reflexed. The powder is believed to be the seeds, which through a microscope appear of a spherical form, and to be annexed to elastic hairs.

LYCOPODIUM, or Club-moss, a genus of the natural order of musci, belonging to the cryptogamia class of plants. The antheræ are bivalved and sessile; there are no calyptra. There are 29 species, of which the following are the most remarkable: 1. The clavatum, or common club-moss, is common in dry and mountainous places, and in fir forests. The stalk is prostrate, branched, and creeping from a foot to two or three yards long; the radicles woody. The leaves are numerous, narrow, lanceolated, acute, often incurved at the extremity, terminated with a long white hair, and every where surround the stalk. The peduncles are erect, firm, and naked, (except being thinly set with lanceolet scales), and arise from the ends of the branches. They are generally two or three inches long, and terminated with two cylindrical yellowish spikes, imbricated with oval-acute scales, finely lacerated on the edges, and ending with a hair. In the ala or bosom of the scale is a kidney-shaped capsule, which bursts with elasticity when ripe, and throws out a light-yellow powder, which, blown into the flame of a candle, flashes with an explosion.

LYCOPSIS, a genus of the monogynia order, in the pentandria class of plants, and in the natural method ranking under the 41st order, asperifoliæ. The corolla has an incurvated tube. There are eight species, chiefly annuals.

LYCOPUS, a genus of the monogynia order, belonging to the diandria class of plants, and in the natural method ranking under the 42d order, verticillatæ. The corolla is quadrifid, with one of the segments emarginated; the stamina standing asunder, with four retuse seeds. There are three species, of which the water-horehound might probably be of use in dyeing.

LYGEUM, a genus of the monogynia order, in the triandria class of plants, and in the natural method ranking under the fourth order, gramina. The spatha or sheath is monophyllous; there are a pair of corollæ upon the same germen; the nut is bilocular. There is one species, a grass of Spain.

LYDIAN STONE, in mineralogy, is commonly intersected by veins of quartz. Fracture even, and sometimes inclining to conchoidal. Specific gravity 2.6 nearly. Powder black, or greyish black. This stone, or one similar to it, was used by the ancients as a touchstone. They drew the metal to be examined along the stone, and judged of its purity by the colour of the metallic streak. On this account it was called Βασανος, the trier. It was called the Lydian stone, as being found in the river Tmolus in Lydia.

LYMPH. See Anatomy, and Physiology.

LYNX. See Felis.

LYRE, Lyra, a musical instrument of the string kind, much used by the ancients.

LYRE, *lyra*, in astronomy, a constellation of the northern hemisphere, the number of whose stars, in Ptolemy's and Tycho's catalogues, are only 10, but 19 in the Britannic catalogue.

LYRIC. See Poetry.

LYSIMACHIA, *loosestrife*, a genus of the monogynia order, in the pentandria class of plants, and in the natural method ranking under the 20th order, rotaceæ. The corolla is rotaceous; the capsule globular, beaked, and ten-valved. There are 12 species, but only four are commonly cultivated in gardens. These are hardy herbaceous perennials and biennials, rising with erect stalks from 18 inches to two or three feet high, and terminated by spikes and clusters of monopetalous, rotated, five-parted spreading flowers of white and yellow colours. The numulana, or yellow moneywort, or herb jevoperee, is particularly beautiful.

LYTHRUM, *purple loosestrife*, a genus of the monogynia order, in the decandria class of plants, and in the natural method ranking under the 17th order, calycanthemæ. The calyx is cleft in 12 parts; and there are six petals inserted into it; the capsule is bilocular and polyspermous. There are 18 species, of which the most remarkable are. 1. The salicaria, or common purple loosestrife, with oblong leaves, is a native of Britain, and grows naturally by the sides of ditches and rivers. 2. The hispanum, or Spanish loosestrife, with a hyssop leaf, grows naturally in Spain and Portugal. The flowers are larger than those of the common sort, and make a fine appearance in the month of July, when they are in beauty.

M.

M, the twelfth letter of our alphabet. As a numeral it stands for mille, a thousand; and with a dash over it, thus $\overline{M}$, for a thousand times a thousand, or 1000000. Used as an abbreviature M. signifies Manlius, Marcus, Martius, Mucius; and M. Manius; M. B. mulier bona; Mag. Eq. magister equitum; Mag. Mil. magister militum; M. M. P. manu mancipio potestate; M. A. magister artium; MS. manuscript, and M. SS. manuscripts, in the plural. In the prescriptions of physicians, M. stands for manipulus, a handful; and sometimes for misce, or mixtura.

MABA, a genus of the triandria order, in the diœcia class of plants. The perianthium of the male is trifid; that of the female is as in the male; the fruit is a plum two-celled, superior. There is one species, a tree of the Friendly islands.

MABEA, a genus of the monoecia polyandria class and order. The calyx is one-leaved; corolla none. There are two species, called pipewood, shrubs of the West Indies.

MACARONIC, or Macaronian, an appellation given to a burlesque kind of poetry, made up of a jumble of words of different languages, and words of the vulgar tongue latinized.

MACE, the second coat or covering of the kernel of the nutmeg, is a thin and membranaceous substance, of an oleaginous nature and a yellowish colour; being met with in flakes of an inch an more in length, which are divided into a multitude of ramifications. It is of an extremely fragrant, aromatic, and agreeable flavour, and of a pleasant, but acrid and oleaginous taste. See Myristica.

MACERATION, in pharmacy, is an infusion of, or soaking ingredients in, water, or any other fluid, in order either to soften them or draw out their virtues.

MACHINE. See Mechanics.

MACKREL. See Scomber.

MACROCNEMON, a genus of the class and order pentandria monogynia. The cor. is bell-shaped; the capsule two-celled, two-valved; seeds imbricate. There are three species, small trees of the West Indies.

MACROLOBIUM, a genus of the class and order triandria monogynia. The calyx is double, pet. five, germ. pedicelled legume. There are three species, trees of Guiana.

MACULÆ, in astronomy, are dark spots appearing on the luminous surfaces of the sun and moon, and even some of the planets. The solar maculæ are dark spots of an irregular and changeable figure, observed in the face of the sun. These were first observed in November and December of the year 1610, by Galileo in Italy, and Harriot in England, unknown to, and independant of, each other, soon after they had made or procured telescopes.

There have been various observations made of the phenomena of the solar maculæ, and hypotheses invented for explaining them. Many of these maculæ appear to consist of heterogeneous parts; the darker and denser being called, by Hevelius, nuclei, which are encompassed as it were with atmospheres, somewhat rarer and less obscure; but the figure, both of the nuclei and entire maculæ, is variable. These maculæ are often subject to sudden mutations. In 1644, Hevelius observed a small thin macula, which in two days time grew to ten times it bulk, appearing also much darker, and having a larger nucleus: the nucleus began to fail sensibly before the spot disappeared; and before it quite vanished, it broke into four, which reunited again two days after. Some maculæ have lasted 2, 3, 10, 15, 20, 30, but seldom 40 days; though Kirchius observed one in 1681, that was visible from April 26th to the 17th of July. It is found that the spots move over the sun's disc with a motion somewhat slacker near the edge than in the middle parts; that they contract themselves near the limb, and in the middle appear larger; that they often run into one in the disc, though separated near the centre; that many of them first appear in the middle, and many disappear there; but that none of them deviate from their path near the horizon; whereas Hevelius, observing Mercury in the sun near the horizon, found him too low, being depressed 27″ beneath his former path.

From these phenomena are collected the following consequences:

1. That since Mercury's depression below his path arises from his parallax, the maculæ, having no parallax from the sun, are much nearer him than that planet.

2. That since they rise and disappear again in the middle of the sun's disc, and undergo various alterations with regard both to bulk, figure, and density, they must be formed de novo, and again dissolved about the sun; and hence some have inferred, that they are a kind of solar clouds, formed out of his exhalations; and if so, the sun must have an atmosphere.

3. Since the spots appear to move very regularly about the sun, it is hence inferred, that it is not that they really move, but that the sun revolves round his axis, and the spots accompany him, in the space of 27 days, 12 hours, 20 minutes.

4. Since the sun appears with a circular disc in every situation, his figure, as to sense, must be spherical.

The magnitude of the surface of a spot may be estimated by the time of its transit over a hair in a fixed telescope. Galileo estimates some spots as larger than both Asia and Africa put together; but if he had known more exactly the sun's parallax and distance, as they are known now, he would have found some of those spots much larger than the whole surface of the earth. For in 1612 he observed a spot so large as to be plainly visible to the naked eye, and therefore it subtended an angle of about a minute. But the earth, seen at the distance of the sun, would subtend an angle of only about 17″; therefore the diameter of the spot was to the diameter of the earth, as 60 to 17, or $3\frac{1}{2}$ to 1 nearly; and consequently the surface of the spot, if circular, to a great circle of the earth, as $12\frac{1}{4}$ to 1, and to the whole surface of the earth, as $12\frac{1}{4}$ to 4, or nearly 3 to 1. Gassendus observed a spot whose breadth was $\frac{1}{20}$ of the sun's diameter, and which therefore subtended an angle at the eye of above a minute and

a half, and consequently its surface was above seven times larger than the surface of the whole earth. He says he observed above forty spots at once, though without sensibly diminishing the light of the sun.

In the year 1779 there was a spot on the sun which was large enough to be seen by the naked eye. It was divided into two parts, and must have been 50,000 miles in diameter.

Various opinions have been formed concerning the nature, origin, and situation of the solar spots; but the most probable seems to be that of Dr. Wilson, professor of practical astronomy in the university of Glasgow. By attending particularly to the different phases presented by the umbra, or shady zone, of a spot of an extraordinary size that appeared on the sun, in the month of November 1769, during its progress over the solar disc, Dr. Wilson was led to form a new and singular conjecture on the nature of these appearances; which he afterwards greatly strengthened by repeated observations. The results of these observations are, that the solar maculæ are cavities in the body of the sun; that the nucleus, as the middle or dark part has usually been called, is the bottom of the excavations; and that the umbra, or shady zone surrounding it, is the shelving sides of the cavity. Dr. Wilson, besides having satisfactorily ascertained the reality of these immense excavations in the body of the sun, has also pointed out a method of measuring the depth of them. He estimates, in particular, that the nucleus or bottom of the large spot above-mentioned, was not less than a semidiameter of the earth, or about 4000 miles below the level of the sun's surface; while its other dimensions were of a much larger extent. He observed that a spot near the middle of the sun's disc is surrounded equally on all sides with its umbra; but that when, by its apparent motion over the sun's disc, it comes near the western limb, that part of the umbra which is next the sun's centre gradually diminishes in breadth, till near the edge of the limb it totally disappears; whilst the umbra on the other side of it is little or nothing altered. After a semi-revolution of the sun on his axis. if the spot appear again, it will be on the opposite side of the disc, or on the left hand. and the part of the umbra which had before disappeared is now plainly to be seen; while the umbra on the other side of the spot seems to have vanished in its turn, being hid from the view by the upper edge of the excavation, from the oblique position of its sloping sides with respect to the eye. But as the spot advances on the sun's disc, this umbra, or side of the cavity, comes in sight; at first appearing narrow. but afterwards gradually increasing in breadth, as the spot moves towards the middle of the disc. These appearances perfectly agree with the phases that are exhibited by an excavation in a spherical body, revolving on its axis; the bottom of the cavity being painted black, and the sides lightly shaded.

Dr. Herschel supposes that the spots in the sun are mountains on its surface, which considering the great attraction exerted by the sun upon bodies placed at its surface. and the slow revolution it has about its axis, he thinks may be more than 300 miles high. He says, that in August 1792 he examined the sun with several powers, from 90 to 500; and it appeared that the black spots are the opaque ground or body of the sun, and that the luminous part is an atmosphere which being broken, gives a glimpse of the sun itself.

MADDER. See Rubia.

MADNESS. See Medicine.

MADREPORA, in natural history, the name of a genus of submarine substances, the characters of which are, that they are almost of a stony hardness, resembling the corals, and are usually divided into branches, and pervious by many holes or cavities, which are frequently of a stellar figure.

In the Linnæan system, this is a genus of lithophyta: the animal that inhabits it is a medusa; it comprehends 39 species. According to Donati, the madrepora is like the coral as to its hardness, which is equal to bone or marble; the colour is white when polished; its surface is lightly wrinkled, and the wrinkles run lengthwise of the branches; in the centre there is a sort of cylinder, which is often pierced through its whole length by two or three holes. From this cylinder are detached about 17 laminæ, which run to the circumference in straight lines; and are transversely intersected by other laminæ, forming many irregular cavities; the cellules, which are composed of these laminæ ranged into a circle, are the habitations of litle polypes, which are extremely tender animals, generally transparent, and variegated with beautiful colours. M. de Peyssonel observes, that those writers who only considered the figures of submarine substances, denominated that class of them which seemed pierced with holes, pora; and those the holes of which were large they called madrepora. He defines them to be all those marine bodies which are of a stony substance, without either bark or crust, and which have but one apparent opening at each extremity, furnished with rays that proceed from the centre to the circumference. He observes that the body of the animal of the madrepora, whose flesh is so soft that it divides upon the gentlest touch, fills the centre; the head is placed in the middle, and surrounded by several feet or claws, which fill the intervals of the partitions observed in this substance, and are at pleasure brought to its head, and are furnished with yellow papillæ. He discovered that its head or centre was lifted up occasionally above the surface, and often contracted and dilated itself like the pupil of the eye: he saw all its claws moved, as well as its head or centre. When the animals of the madrepora are destroyed, its extremities become white. In the madrepora, he says, the animal occupies the extremity, and the substance is of a stony but more loose texture than the coral. This is formed, like other substances of the same nature, of a liquor which the animal discharges: and he father adds. that there are some species of the polype of the madrepora which are produced singly, and others in clusters. See Plate LXXXIV. Nat. Hit. figs. 256, 257; and Zoophytes.

MADREPORITE, a mineral found in the valley of Russback in Salzburg, and which obtained its name from its resemblance to madrepore. Colour in some parts black. in others dark-grey. Found in large round masses. Fracture even, passing to the conchoidal. Lustre greasy, passing to the silky. Brittle: moderately heavy. Streak grey; it is composed of

93.00 carbonat of lime
0.50 carbonate of magnesia
7.25 carbonat of iron

0.50 charcoal
4.50 silica in sand.

99.75

MADRIER, in the military art, a long and broad plank of wood, used for supporting the earth in mining and carrying on a sap, and in making coffers, caponiers, galleries, and for many other uses at a seige. Madriers are also used to cover the mouths of petards after they are loaded, and are fixed with the petards to the gates or places designed to be forced open.

MÆMACTERION, the fourth month of the Athenian year consisting of only 29 days, and answering to the latter part of September and the beginning of October.

MAGAZINE, a place in which stores are kept, or arms, ammunition, provisions, &c. Every fortified town ought to be furnished with a large magazine, which should contain stores of all kinds, sufficient to enable the garrison and inhabitants to hold out a long siege, and in which smiths, carpenters, wheel-wrights, bakers, &c. may be employed in making every thing belonging to the artillery, as carriages, waggons, &c.

Magazine, *powder*, is that place where the powder is kept in very large quantities. Authors differ greatly both in regard to situation and construction; but all agree, that they ought to be arched, and bomb-proof. In fortifications they are frequently placed in the rampart; but of late they have been built in different parts of the town. The first powder-magazines were made with Gothic arches; but M. Vauban, finding them too weak, constructed them in a semicular form, whose dimensions are 60 feet long within, 25 broad; the foundations are eight or nine feet thick, and eight feet high from the foundation to the spring of the arch; the floor is two feet from the ground, which keeps it from dampness.

An English engineer of great experience, some time since, had observed, that after the centres of semicircular arches are struck, they settle at the crown, and rise up at the haunches, even with a straight horizontal extrados; and still much more so in powder-magazines, whose outside at top is formed like the roof of a house, by two inclined planes joining in an angle over the top of the arch, to give a proper descent to the rain; which effects are exactly what might be expected agreeable to the true theory of arches. Now, as this shrinking of the arches must be attended with very ill consequences, by breaking the texture of the cement after it has been in some degree dried, and also by opening the joints of the voussoirs at one end, so a remedy is provided for this inconvenience, with regard to bridges, by the arch of equilibration in Dr. Hutton's book on bridges; but as the ill effect is much greater in powder-magazines, the same ingenious gentleman proposed to find an arch of equilibration for them also, and to construct it when the span is 20 feet, the pitch or height 10 (which are the same dimensions as the semicircle), the inclined exterior walls at top forming an angle of 113 degrees, and the height of their angular point above the top of the arch equal to seven feet.

MAGI, or Magians, an ancient religious sect in Persia, and other Eastern countries, who maintained, that there were two principles, the one the cause of all good, the other the cause of all evil; and abominating the adoration of all images, worshipped God only by fire, which they looked upon as the brightest and most glorious symbol of Oromasdes, or the good God: as darkness is the truest symbol of Arimanius, or the evil God. This religion was reformed by Zoroaster. The sect still subsists in Persia, under the denomination of gaurs.

MAGIC Lantern. See Optics.

Magic Square, in arithmetic, a square figure made up of numbers in arithmetical proportion, so disposed in parallel and equal ranks, that the sums of each row, taken either perpendicularly, horizontally, or diagonally, are equal: thus,

Natural square.

1	2	3
4	5	6
7	8	9

Magic square.

2	7	6
9	5	1
4	[illegible]	[illegible]

Magic squares seem to have been so called, from their being used in the construction of talismans.

MAGNA CHARTA, the great charter of the liberties of England, and the basis of their laws and privileges.

This charter may be said to derive its origin from king Edward the Confessor, who granted several privileges to the church and state, by charter; these liberties and privileges were also granted and confirmed by king Henry I., by a celebrated great charter now lost; but which was confirmed or re-enacted by king Henry II. and king John. Henry III., the successor of this last prince, after having caused twelve men to make inquiry into the liberties of England in the reign of Henry I., granted a new charter, which was the same as the present Magna Charta; this he several times confirmed, and as often broke; till in the thirty-seventh year of his reign, he went to Westminster-hall, and there, in the presence of the nobility and bishops, who held lighted candles in their hands, Magna Charta was read, the king all the while holding his hand to his breast, and at last solemnly swearing faithfully and inviolably to observe all the things therein contained, &c.; then the bishops extinguishing the candles, and throwing them on the ground, cried out, "Thus let him be extinguished, and stink in hell, who violates this charter." It is observed, that notwitstanding the solemnity of this confirmation, king Henry, the very next year, again invaded the rights of his people, till the barons entered into a war against him; when, after various success, he confirmed this charter, and the charter of the forest, in the fifty-second year of his reign. This excellent charter, so equitable and beneficial to the subject, is the most ancient written law in the kingdom: by the 25 Edw. I. it is ordained, that it shall be taken as the common law; and by the 43 Edw. III. all statutes made against it are declared to be void.

MAGNESIA. About the beginning of the eighteenth century, a Roman canon exposed a white powder to sale at Rome as a cure for all diseases. This powder he called magnesia alba. He kept the manner of preparing it a profound secret; but in 1707 Valentini informed the public that it might be obtained by calcining the lixivium which remains after the preparation of nitre: and two years after, Slevogt discovered that it might be precipitated by potass from the mother-ley of nitre. This powder was generally supposed to be lime, till Frederic Hoff-

man observed that it formed very different combinations with other bodies. But little was known concerning its nature, and it was even confounded with lime by most chemists, till Dr. Black made his celebrated experiments on it in 1755. Margraff published a dissertation on it in 1759, and Bergman another in 1775, in which he collected the observations of these two philosophers, and which he enriched also with many additions of his own. Butini of Geneva likewise published a valuable dissertation on it in 1779.

As magnesia has never yet been found native in a state of purity, it may be prepared in the following manner: sulphat of magnesia, a salt composed of this earth and sulphuric acid, exists in sea-water, and in many springs, particularly in some about Epsom; from which circumstance it was formerly called Epsom salt. This salt is to be dissolved in water, and half its weight of potass added. The magnesia is immediately precipitated, because potass has a stronger affinity for sulphuric acid. It is then to be washed with a sufficient quantity of water, and dried.

Magnesia thus obtained is a very soft white powder, which has very little taste, and is totally destitute of smell. Its specific gravity is about 2.3. It converts delicate vegetable blues (paper for instance, stained with the petals of the mallow) to green.

It is not melted by the strongest heat which it has been possible to apply; but M. Darcet observed that, in a very high temperature, it became somewhat agglutinated. When formed into a cake with water, and then exposed to a violent heat, the water is gradually driven off, and the magnesia contracts in its dimension; at the same time it acquires the property of shining in the dark when rubbed upon a hot iron plate.

It is almost insoluble in water; for, according to Mr. Kirwan, it requires 7900 times its weight of water at the temperature of 60° to dissolve it. It is capable, however, of combining with water in a solid state; for 100 parts of magnesia, thrown into water, and then dried, are increased in weight to 118 parts. Even when combined with carbonic acid (for which it has a strong affinity) it is capable of absorbing and retaining $1\frac{1}{2}$ times its own weight of water without letting go a drop; but on exposure to the air, this water evaporates, though more slowly than it would from lime.

Magnesia has never yet been obtained in a crystallized form.

When exposed to the air, it attracts carbonic acid gas and water; but exceedingly slowly. Butini left a quantity of it for two years in a porcelain cup merely covered with paper; its weight was only increased $\frac{1}{144}$ part.

Magnesia does not combine with oxygen; nor is it altered by any of the compounds into which oxygen enters. The only one of the simple combustibles with which it can be united is sulphur. No person has hitherto succeeded in forming a phosphuret of magnesia. The sulphuret of magnesia may be formed by exposing a mixture of two parts of magnesia and one part of sulphur, to a gentle heat in a crucible. The result is a yellow powder, slightly agglutinated, which emits very little sulphureted hydrogen gas, when thrown into water. A moderate heat is sufficient to drive off the sulphur.

Magnesia does not combine with azote, but it unites with muriatic acid, and forms a compound called muriat of magnesia. It has no action upon the metals: nor does it combine, as far as is known at present, with the metallic oxides, unless some intermediate substance is present. It does not combine with the fixed alkalies, neither are its properties altered by these bodies; but it has a strong propensity to enter into triple compounds with ammonia.

There seems to be little affinity between magnesia and barytes; at least no mixture of the two earths is fusible in the strongest heat which it has been possible to apply.

Mr. Kirwan has shown that there is but little affinity between strontian and magnesia. They do not melt when exposed to a strong heat, at least when the strontian exceeds or equals the magnesia.

Equal parts of lime and magnesia, mixed together, and exposed by Lavoisier to a very violent heat, did not melt; neither did they melt when Mr. Kirwan placed them in the temperature of 150° Wedgewood.

The affinities of magnesia, according to Bergman, are as follows:

Oxalic acid,	Tartaric,
Phosphoric,	Citric,
Sulphuric,	Lactic,
Fluoric,	Benzoic,
Arsenic,	Acetic,
Saclactic,	Boracic,
Succinic,	Sulphurous,
Nitric,	Carbonic,
Muriatic,	Prussic.

Magnesia is used in medicine, to remove acidities.

MAGNETISM. The natural magnet, or loadstone, is a hard mineral body of a dark brown, or almost black colour, and when examined, is found to be an ore of iron. It is met with in various countries, generally in iron mines, and of all sizes and forms.

This singular substance was known to the ancients; and they had remarked its peculiar property of attracting iron, though it does not appear that they were acquainted with the wonderful property which it also has, of turning to the pole when suspended, and left at liberty to move freely.

Upon this remarkable circumstance the mariner's compass depends, an instrument which gives us such infinite advantages over the ancients. It is this which enables the mariners to conduct their vessels through vast oceans out of the sight of land, in any given direction: and this directive property also guides the miners in their subterranean excavations, and the traveller through desarts otherwise impassable.

It is not precisely known when and by whom this directive property of the magnet was discovered. The most probable accounts seem to prove, that it was known early in the 13th century; and that the person who first made mariner's compasses, at least in Europe, was a Neapolitan of the name of Flavio, or John de Gioga, or Giova, or Gira.

The natural loadstone has also the quality of communicating its properties to iron and steel; and when pieces of steel properly prepared are touched, as it is called, by the loadstone, they are denominated artificial magnets.

These artificial magnets are even capable of being

made more powerful than the natural ones; and as they can be made of any form, and are more convenient, they are now universally used, so that the loadstone or natural magnet is only kept as a curiosity.

All magnets, whether natural or artificial, are distinguished from other bodies by the following characteristics, which appear to be inseparable from their nature; so that no body can be called a magnet, unless it is possessed of all these properties:

1. A magnet attracts iron.

2. When a magnet is placed so as to be at liberty to move freely in every direction, its ends point towards the poles of the earth, or very nearly so; and each end always points to the same pole. This is called the polarity of the magnet; the ends of the magnet are called poles; and they are called north and south poles of the magnet, according as they point to the north or south pole of the earth. When a magnet places itself in this direction, it is said to traverse.

3. When the north pole of one magnet is presented to the south of another magnet, these ends attract each other; but if the south pole of one magnet is presented to the south pole of another, or the north pole of one to the north pole of another, these ends will repel each other.

From these criteria, it is easy to determine the names of the poles of a magnetical bar, by applying it near a suspended magnet whose poles are known.

4. When a magnet is situated so as to be at liberty to move itself with sufficient freedom, its two poles do not lie in a horizontal direction, but it generally inclines one of them towards the horizon, and of course it elevates the other pole above it. This is called the inclination or dipping of the magnet.

5. Any magnets may, by proper methods, be made to impart those properties to iron or steel.

A plane perpendicular to the horizon, and passing through the poles of a magnet when standing in their natural direction, is called the magnetic meridian; and the angle which the magnetic meridian makes with the meridian of the plane where the magnet stands, is called the declination of the magnet at that place.

Of magnetic attraction and repulsion.—When a piece of iron is brought within a certain distance of one of the poles of a magnet, it is attracted by it; and if the iron is at liberty to move, it adheres to the magnet, and cannot be separated without some force. It appears at first sight, that the attraction lies only in the magnet, but experiment proves this attraction to be mutual; the iron attracting the magnet as much as the magnet attracts the iron. Place the magnet and the iron upon two separate pieces of cork, or wood, floating upon water, at a little distance from each other, and it will be found that the iron moves towards the magnet, as well as the magnet towards the iron; but if the iron is kept steady, the magnet will move towards it.

This attraction is strongest at the poles of a magnet, and diminishes in proportion to the distance of any part from the poles, so that in the middle between the poles there is no attraction. This may be easily perceived by presenting a piece of iron to various parts of the surface of a magnet.

The intensity of the attractive power diminishes also, according to the distance from the magnet. If the magnet and iron touch each other, it requires a certain degree of force to separate them; if the iron is removed a little way from the magnet, an attraction will be plainly perceived, but not so powerful; and by increasing this distance the attraction will be much diminished.

The law of diminution of this attraction is not yet known. Some have imagined that it diminishes in proportion to the square of the distance, others as the cube of the distance. But either from the difficulty of the subject, on account of the experiments having been made without sufficient accuracy, the question remains yet undecided; it is only known that the attractive force decreases faster than the simple ratio of the distances.

As magnetic attraction takes place only between poles of different names of different magnets; that is, the north pole of one magnet attracts the south pole of another; consequently magnetic repulsion acts only between poles of the same name of different magnets. Thus, if the north pole of one magnet is opposed to the north pole of another magnet, or if the south pole be opposed to the south pole of the other, then those magnets will repel each other, and that nearly with as much force as the poles of different names would attract each other.

But it frequently happens, that though magnets are placed with the same poles towards each other, yet they either attract each other, or show a perfect indifference. This, at first, seems to contradict the above-mentioned general law; but this difficulty is removed by the following considerations:

When a piece of iron is brought within a certain distance of a magnet, it becomes, in fact, itself a magnet, having the polarity, the attractive and repulsive properties for other iron, &c.; that part of it which is nearest to the south pole of the magnet, becoming a north pole, and the opposite part a south pole, or vice versa, according to the end of the magnet presented. Thus if A B, Plate LXXX. Magnetism, fig. 1, be an oblong piece of iron, and be brought near the north pole N of the magnet NS, then this piece of iron while standing within the magnet's sphere of action, will have all the properties of a real magnet, and its end A will be found to be a south pole, while the end B is a north pole.

Soft iron, when placed within the influence of a magnet, easily acquires these properties; but they last only while the iron remains in that situation, and when it is removed its magnetism vanishes immediately. But with iron containing carbon, and particularly with steel, the case is very different; and the harder the iron or the steel is, the more permanent is the magnetism which it acquires from the influence of a magnet; but it will be in the same proportion more difficult to render it magnetic.

If a piece of soft iron, and a piece of hard steel, both of the same shape and size, are brought within the influence of a magnet at the same distance, it will be found that the iron is attracted more forcibly, and appears more powerfully magnetic than the steel; but if the magnet is removed, the soft iron will instantly lose its acquired properties, whereas the hard steel will preserve them for a long time, having become an artificial magnet.

Neither the magnetic attraction nor repulsion is in the least diminished, or at all affected, by the interposition

of any sort of bodies, except iron, or such bodies as contain iron.

The properties of the magnet are not affected either by the presence or by the absence of air. Heat weakens the power of a magnet, and subsequent cooling restores it, but not quite to its former degree. A white heat destroys it entirely, or very nearly so; and hence it appears, that the powers of magnets must be varying continually. Cavallo observes, that iron in a full red heat, or white heat, is not attracted by the magnet; but the attraction commences as soon as the redness begins to appear.

The attractive power of a magnet may be considerably improved by suspending a weight of iron to it by its power of attraction, which may be gradually increased; and also by keeping it in a proper situation, viz. with its north pole towards the north, and its south pole, consequently, towards the south. On the contrary, this power is diminished by an improper situation, and by keeping too small a piece of iron, or no iron at all, appended to it.

In these northern parts of the world, the north pole of a magnet has more power than its south pole; whereas, the contrary effect has been said to take place in the southern parts.

Amongst the natural magnets, the smallest generally possess a greater attractive power in proportion to their size than those of a larger size.

It frequently happens, that a natural magnet, cut off from a larger loadstone, will be able to lift a greater weight of iron than the original loadstone itself.

As both magnetic poles together attract a much greatweight than a single pole; and as the two poles of a magnet generally are in opposite parts of its surface, in which case it is almost impossible to adapt the same piece of iron to them both at the same time; therefore it has been commonly practised to adapt two broad pieces of soft iron to the poles of the stone, and to let them project on one side of the stone; for those pieces become themselves magnetic while thus situated, and to them the piece of iron or weight may be easily adapted. Those two pieces of iron are generally fastened upon the stone by means of a brass or silver box. The magnet in this case is said to be armed, and the two pieces of iron are called the armature.

Fig. 2. represents an armed magnet, where A B is the loadstone: C D, C D, are the armature, or the two pieces of soft iron, to the projections of which D D the iron weight F is to be applied. The dots E C D C D represent the brass box, with a ring at E, by which the armed magnet may be suspended.

Artificial magnets, when straight, are sometimes armed in the same manner; but they are frequently made in the shape of a horse-shoe, having their poles at the truncated extremities, as at N and S, fig. 3, in which shape it is evident that they want no armature.

Most probably the magnet attracts iron only; but when it is considered how universally iron is dispersed throughout nature, it is evident that a vast number of bodies must on that account be attracted by the magnet more or less forcibly, in proportion to the quantity and quality of the iron they contain. Indeed, it is wonderful to observe what a small portion of iron will render a body subject to the influence of the magnet.

The polarity of the magnet.—Every magnet has a south and a north pole, which are at opposite ends; and a line drawn from one end to the other, passes through the centre of the magnet. Here it must not be understood, that the polarity of a magnet resides only in two points of its surface; for in reality, it is the one half of the magnet that is possessed of one kind of polarity, and the other half of the other kind of polarity; the poles, then, are those points in which that power is the strongest.

The line drawn from pole to the other, is called the axis of the magnet; and a line formed all round the surface of the magnet, by a plane which divides the axis into two equal parts, and is perpendicular to it, is called the equator of the magnet.

It is the polarity of the magnet that renders it so useful to navigators. When a magnet is kept suspended freely, so that it may turn north and south, the pilot, by looking at the position of it, can steer his course in any required direction. Thus, if a vessel is steered towards a certain place which lies exactly westward of that from which it set out, the navigator must direct it so, that its course may be always at right angles with the direction of the magnetic needle of his compass, keeping the north end of the magnet on the right-hand side, and of course, the the south end on the left-hand side of the vessel; for as the needle points north and south, and the direction is east and west, the intended course of the vessel is exactly perpendicular to the position of the magnet. A little reflection will show how the vessel may be steered in any other direction.

An artificial magnet fitted up in a proper box, for the purpose of guiding the direction of a traveller, is called a magnetic needle, and the whole together is called the mariner's compass.

Although the north pole of the magnet in every part of the world, when suspended, points towards the northern parts, and the south pole towards the southern parts, yet its ends seldom point exactly towards the poles of the earth. The angle in which it deviates from due north and south, is called the angle of declination, or the declination of the magnetic needle, or the variation of the compass; and this declination is said to be east or west, according as the north pole of the needle is eastward or westward of the astronomical meridian of the place.

This deviation from the meridian is not the same in all parts of the world, but is different in different places, and it is even continually varying in the same place. For instance, this declination is not the same in London as at Paris, or as in India; and the declination in London, or in any other place, is not the same at this time as it was some years ago. This declination from the meridian is so variably, that it may be observed to change, even in one or two hours time; and this is not owing to the construction of the magnetic needle; for in the same place, and at the same time, all true magnetic needles point the same way.

The declination from the meridian, and the variation of this in different parts of the world, are very uncertain, and cannot be foretold; actual trial is the only method of ascertaining them. This circumstance forms a great impediment to the improvement of navigation. It is true,

that great pains have been taken by navigators and other observers, to ascertain the declination in various parts of the world, and such declinations have been marked in maps, charts, books, &c.; but still, on account of the constant change to which this variation is liable, these can only serve for a few years; nor has the law of this variation or fluctuation been yet discovered, though various hypotheses have been formed for that purpose. When the variation was first observed, the north pole of the magnetic needle declined eastward of the meridian of London; but it has since that time been changing continually towards the west; so that in the year 1657 the magnetic needle pointed due north and south. At present, it declines about $24\frac{1}{2}''$ westward, and it seems to be still advancing towards the west.

Before volcanic eruptions and earthquakes, the magnetic needle is often subject to very extraordinary movements.

It is also agitated before and after the appearance of the aurora borealis.

The magnetic inclination or dip of the needle.—If a needle which is accurately balanced, and suspended so as to turn freely in a vertical plane, is rendered magnetical, the north pole will be depressed, and the south pole elevated above the horizon: this property is called the inclination, or dip of the needle, and was discovered by Robert Norman, about the year 1576.

Take a globular magnet, or, which is more easily procured, an oblong one, like SN, fig. 4; the extremity N of which is the north pole, the other extremity S is the south pole, and A is its middle or equator; place it horizontally upon a table CD: then take another small oblong magnet *ns* (viz. a bit of steel wire, or a small sewing-needle magnetized) and suspend it by means of a fine thread tied to its middle, so as to remain in an horizontal position, when not disturbed by the vicinity of iron, or other magnet. Now if the same small magnet, being held by the upper part of the thread, be brought just over the middle of the large magnet, within two or three inches of it, the former will turn its south pole *s*, towards the north pole, N, of the large magnet; and its north pole *n*, towards the south pole, S, of the large one. It will be farther observed, that the small magnet, whilst kept just over the middle A of the large one, will remain parallel to it; for since the poles of the small magnet are equally distant from the contrary poles of the large magnet, they are equally attracted. But if the small magnet be moved a little nearer to one end than to the other of the large magnet, then one of its poles, namely, that which is nearest to the contrary pole of the large magnet, will be inclined downwards, and of course the other pole will be elevated above the horizon. It is evident that this inclination must increase according as the small magnet is placed nearer to one of the poles of the large one; because the attraction of the nearest pole will have more power upon it. If the small magnet be brought just opposite to one of the poles of the large magnet, it will turn the contrary pole towards it; and will place itself in the same straight line with the axis of the large magnet.

This simple experiment will enable the reader to comprehend easily the phenomena of the magnetic inclination, or of the dipping needle, upon the surface of the earth; for it is only necessary to imagine that the earth is a large magnetic (as in fact it appears to be), and that any magnet, or magnetic needle, commonly used, is the small magnet employed in the above-mentioned experiment; for, supposing that the north pole of the earth is possessed of a south magnetic polarity, and that the opposite pole is possessed of a north magnetic polarity, it appears evident, and it is confirmed by actual experience, that when a magnet, or magnetic needle, properly shaped and suspended, is kept near the equator of the earth (since neither the magnetic equator nor the magnetic poles of the earth, coincide with its real equator and poles), it must remain in a horizontal situation: if the magnet is removed nearer to one of the magnetic poles of the earth, it must incline to one of its extremities, namely, that which is possessed of the contrary polarity; and this inclination must increase in proportion as the needle recedes from the magnetic equator of the earth. Lastly, when the needle is brought exactly over one of the magnetic poles of the earth, it must stand perpendicular to the horizon of that place.

A magnetic needle constructed for the purpose of showing this property, is called a dipping-needle, and its direction in any place is called the magnetical line. When it was said, that the north pole of the earth possessed south polarity, it was only meant that it had a polarity contrary to that end of the magnetic needle which is directed towards it.

If the geographical poles of the earth (that is, the ends of its axis), coincided with its magnetic poles; or even if the magnetic poles were constantly at the same distance from them; the inclination of the needle, as well as its declination, would always be the same; and hence, by observing the direction of the magnetic needle in any particular place, the latitude and longitude of that place might be ascertained; but this is not the case, for the magnetic poles of the earth do not coincide with its real poles, and they are also certainly shifting their situation; hence the magnetic needle changes continually and irregularly, not only in its horizontal direction, but likewise in its inclination, according as it is removed from one place to another, and also while it remains in the very same place.

This change of the dip in the same place, however, is very small. In London, about 1576, the north pole of the dipping needle stood 71° 50′ below the horizon; and in 1775, it stood at 72° 3′; the whole change of inclination, during so many years, amounting to less than a quarter of a degree.

There are various methods of giving the magnetic property to steel or iron. In some cases, it appears to be acquired without the use of another magnet.

If you take a bar of iron three or four feet long, and hold it in a vertical position, you will find that the bar is magnetic, and will act upon another magnet; the lower extremity of the bar attracting the south pole, and repelling the north pole. If you invert the bar, the polarity will be instantly reversed; the extremity which is now lowest, will be found to be a north pole, and the other extremity will be a south pole.

A bar of hard iron, or steel, will not answer for the above experiment, the magnetism of the earth not being sufficient to magnetise it.

Bars of iron that have stood in a perpendicular position,

are generally found to be magnetical; as fire-irons, bars of windows, &c.

If a long piece of hard iron is made red-hot, and then left to cool in the direction of the magnetical line, it becomes magnetical.

Striking an iron bar with a hammer, or rubbing it with a file, while held in this direction, likewise renders it magnetical. An electric shock produces the same effect; and lightning often renders iron magnetic.

A magnet cannot communicate a degree of magnetism stronger than that which itself possesses; but two or more magnets, joined together, may communicate a greater power to a piece of steel, than either of them possesses singly: hence we have a method of constructing very powerful magnets, by first constructing several weak artificial magnets, and then joining them together to form a compound magnet, and to act more powerfully upon a piece of steel.

1. Place two magnetic bars, A, B, fig. 5. in a line with the north, or marked end of one, opposed to the south, or unmarked end of the other; but at such a distance from each other, that the magnet to be touched may rest with its marked end on the unmarked end of A, and its unmarked end on the marked end of B; then apply the north end of the magnet E, and the south end of D, to the middle of the bar C, the opposite ends being elevated as in the figure; draw E and D asunder along the bar C, one towards A, the other towards B, preserving the same elevation; remove E and D a foot or two from the bar when they are off the ends, then bring the north and south poles of these magnets together, and apply them again to the middle of the bar C as before: repeat the same process five or six times, then turn the bar, and touch the opposite surface in the same manner, and afterwards the two remaining surfaces; by this means the bar will acquire a strong fixed magnetism.

2. Place the two bars which are to be touched parallel to each other; and then unite the ends by two pieces of soft iron, called supporters, in order to preserve, during the operation, the circulation of the magnetic matter; the bars are to be placed so that the marked end D (fig. 6), may be opposite the unmarked end B; then place the two attracting poles G and I on the middle of one of the bars to be touched, raising the ends so that the bars may form an obtuse angle of 100 or 120 degrees; the ends G and I of the bars are to be separated two or three tenths of an inch from each other. Keeping the bars in this position, move them slowly over the bar AB, from one end to the other, going from end to end about fifteen times. Having done this, change the poles of the bars (*i. e.* the marked end of one is always to be against the unmarked end of the other), and repeat the same operation on the bar CD, and then on the opposite faces of the bars. The touch thus communicated may be further increased, by rubbing the different faces of the bars with sets of magnetic bars, disposed as in fig. 7.

In these operations all the pieces should be well polished, the sides and ends made quite flat, and the angels quite square.

A magnet bent so that the two ends almost meet, is called a horse-shoe magnet, fig. 3. To rendar it magnetic, place a pair of magnetic bars against the ends of the horse-shoe, with the south end of the bar against that of the horse-shoe which is intended to be the north, and the north end of the bar to that which is to be the south; the contact, or lifter of soft iron, to be placed at the other end of the bars. Also rub the surfaces of the horse-shoe with a pair of bars placed in the form of a compass, or with another horse-shoe magnet, turning the poles properly to the poles of he horse-shoe magnet; being careful that these bars never touch the ends of the straight bars. If the bars are separated suddenly from the horse-shoe magnet, its force will be considerably diminished; to prevent this, slip on the lifter, or support, to the end of the horse-shoe magnet, but in such a manner, however, that it may not touch the bars; the bars may then be taken away, and the support slid to its place.

Magnetism is best communicated to compass-needles by the two following methods:

Procure a pair of magnetic bars, not less than six inches in length. Fasten the needle down on a board, and with a magnet in each hand draw them from the centre upon the needle outwards; then raise the bars to a considerable distance from the needle, and bring them perpendicularly down upon the centre, and draw them over again. This operation repeated about twenty times will magnetize the needle, and its ends will point to the poles contrary to those that touched them.

Over one end of a combined horse-shoe magnet, of at least two in number, and six inches in length, draw from its centre that half of the needle which is to have the contrary pole to the end of the magnet: raise the needle to a considerable distance, and draw it over the magnet again; this repeated about twenty times at least, and the same for the other half, will sufficiently communicate the power.

A set of bars are exceedingly useful for magnetizing other bars, or needles of compasses, &c. their power may also be increased when lost or impaired by mismanagement, &c. A set of such bars, viz. six bars and the two iron conductors, may be preserved in a box; taking care to place the north pole of one contiguous to the south pole of the next, and that contiguous to the north pole of the third, &c. as shown in fig. 8.

After what has been said above, we need not describe how a knife, or any other piece of steel, &c. may be rendered magnetic, or in what manner a weak magnet may be rendered more powerful. But it may perhaps be necessary to say something concerning the communication of magnetism to crooked bars like ABC, fig. 9.

Place the crooked bar flat upon a table, and to its extremities apply the magnetic bars DF, EG; joining their extremities FG, with the conductor or piece of soft iron FG; then to its middle apply the magnetic bars placed at an angle: or you may use two bars only, placed as shown in fig. 9, and stroke the crooked bar with them from end to end, following the direction of that bent bar; so that on one side of it the magnetic bars may stand in the direction of the dotted representation LK. In this manner, when the piece of steel ABC has been rubbed a sufficient number of times on one side, it must be turned with the other side upwards, &c.

In communicating magnetism, it is best to use weak magnets first, and those that are stronger afterwards; but you must be very careful not to use weak after strong magnets.

A magnet loses nothing of its own power by communicating to other substances, but is rather improved.

Every kind of violent percussion weakens the power of a magnet. A strong magnet has been entirely deprived of its virtue, by receiving several smart strokes of a hammer; indeed, whatever deranges or disturbs the internal pores of a magnet will injure its magnetic force.

Fill a small dry glass tube with iron filings, press them in rather close, and then touch the tube as if it was a steel bar, and the tube will attract a light needle; shake the tube, so that the situation of the filings may be disturbed, and the magnetic virtue will vanish.

Magnets should never be left with two north or two south poles together; for when they are thus placed, they diminish and destroy each other's power. Magnetic bars should therefore be always left with the opposite poles laid against each other, or by connecting their opposite poles by a bar of iron. The power of a magnet is increased by letting a piece of iron remain attached to one or both of its poles. A single magnet should therefore be always thus left.

The difference of steel in receiving magnetism is very great, as is easily proved by touching in the same manner, and with the same bars, two pieces of steel of equal size, but of different kinds. With some sort of steel, a few strokes are sufficient to impart to them all the power they are capable of receiving; other sorts require a longer operation; sometimes it is impossible to give them more than a small degree of magnetism.

A piece of spring-tempered steel will not retain as much magnetism as hard steel; soft steel still less, and iron retains scarcely any. Iron when oxydated loses its magnetism.

The construction and the use of the principal magnetical instruments. &c.—The magnetical instruments may be reduced to three principal heads; viz. 1st. the magnets or magnetic bars, which are necessary to magnetize needles of compasses, or such pieces of steel, iron, &c. as may be necessary for divers experiments; and which have already been sufficiently explained in the preceding pages: 2dly, the compasses, such as are used in navigation, and for other purposes, which are only magnetic needles justly suspended in boxes, and which, according to the purposes for which they are particularly employed, have several appendages, or differ in size, and in accuracy of divisions, &c. whence they derive the different names of pocket compasses, steering compasses, variation compasses, and azimuth compasses: and 3dly, the dipping needle.

The magnetic needles which are commonly used at sea, are between four and six inches long; but those which are used for observing the daily variation, are made a little longer, and their extremities point the variation upon an arch or circle properly divided and affixed to the box.

The best shape of a magnetic needle is represented in figs. 10 and 11; the first of which shows the upper side, and the second shows a lateral view of the needle, which is of steel, having a pretty large hole in the middle, to which a conical piece of agate is adapted by means of a brass piece O, into which the agate-cap (as it is called) is fastened. Then the apex of this hollow cap rests upon the point of a pin F, which is fixed in the centre of the box, and upon which the needle, being properly balanced, turns very nimbly. For common purposes, those needles have a conical perforation made in the steel itself, or in a piece of brass which is fastened in the middle of the needle.

A mariner's compass. or compass generally used on board of ships, is represented in fig. 12. The box, which contains the card or fly with the needle, is made of a circular form, and either of wood, or brass, or copper. It is suspended within a square wooden box, by means of two concentric circles, called gimbalds, so fixed by cross axes *a, a, a, a,* to the two boxes (see the plan, fig. 13), that the inner one, or compass-box, shall retain a horizontal position in all motions of the ship, whilst the outer or square box is fixed with respect to the ship. The compass box is covered with a pane of glass, in order that the motion of the card may not be disturbed by the wind. What is called the card (fig. 14), is a circular piece of paper, which is fastened upon the needle, and moves with it. Sometimes there is a slender rim of brass, which is fastened to the extremities of the needle, and serves to keep the card stretched. The outer edge of this card is divided into 360 equal parts or degrees, and within the circle of those divisions it is again divided into 32 equal parts, or arcs, which are called the points of the compass, or rhumbs, each of which is often subdivided into quarters. The initial letters N, NE, &c. are annexed to those rhumbs, to denote the north, north-east, &c. The middlemost part of the card is generally painted with a sort of star, whose ray terminate in the above-mentioned divisions. To avoid confusion those letters, &c. are not drawn in the figure.

The azimuth compass is nothing more than the above-mentioned compass, to which two sights are adapted, through which the sun is to be seen, in order to find its azimuth, and from thence to ascertain the declination of the magnetic needle at the place of observation; see fig. 15. The particulars in which it differs from the usual compass, are the sights F, G; in one of which, G, there is an oblong aperture with a perpendicular thread or wire stretched through its middle; and in the other sight F, there is a narrow perpendicular slit. The thread or wire HI is stretched from one edge of the box to the opposite. The ring AB of the gimbalds rests with its pivots on the semicircle CD, the foot E of which turns in a socket, so that whilst the box KLM is kept steady, the compass may be turned round, in order to place the sights F, G, in the direction of the sun.

The pivots of the gimbalds of this, as well as of the common sort of compasses, should lie in the same plane with the point of suspension of the needle, in order to avoid as much as possible the irregularity of the vibrations.

There are, on the inside of the box, two lines drawn perpendicularly along the sides of the box, just from the points where the thread HI touches the edge of the box. These lines serve to show how many degrees the north or south pole of the needle is distant from the azimuth of the sun; for which purpose, the middle of the apertures of the sights F, G, the thread HI, and the said lines, must be exactly in the same vertical plane. The use of the thread HI. which is often omitted in instruments of this sort, is likewise to show the degrees between the

magnetic meridian and the azimuth; when the eye of the observer stands perpendicularly over it. On the side of the box of this sort of compasses, there generally is a nut or stop, which, when pushed in, bears against the card and stops it, in order that the divisions of the card which coincide with the lines in the box, may be more commodiously read off.

The dipping-needle, though of late much improved, is however still far from perfection. The general mode of constructing it is to pass an axis quite through the needle, to let the extremities of this axis, like those of the beam of a balance, rest upon its supports, so that the needle may move itself vertically round, and when situated in the magnetic meridian, it may place itself in the magnetic line. The degrees of inclination are shown upon a divided circle, in the centre of which the needle is suspended. Fig. 16 represents a dipping-needle of the simplest construction; AB is the needle, the axis of which FE rests upon the middle of two lateral bars CD, CD, which are made fast to the frame that contains the divided circle AIBK. This machine is fixed on a stand G; but, when used at sea, it is suspended by a ring H, so as to hang perpendicularly. When the instrument is furnished with a stand, a spirit-level O is generally annexed to it, and the stand has three screws, by which the instrument is situated so that the centre of the motion of the needle, and the division of 90° on the lower part of the divided circle, may be exactly in the same line, perperdicular to the horizon. See Level.

The few experiments which follow, are principally intended to illustrate the theory.

Ex. 1. The method of discovering whether a body is attractable by the magnet or not, and whether it has any polarity or not, or which is its south, and which is its north pole, is so easily performed as not to require many words; for by approaching a magnet to the body in question (which, if necessary, may be set to swim upon water), or by presenting the body in question to either ex-extremity of a suspended magnetic needle, the desired object may be obtained.

Ex. 2. Tie two pieces of soft iron wire, AB, AB, fig. 17 and 18, each to a separate thread, AC, AC, which join at top, and forming them into a loop, suspend them so as to hang freely. Then bring the marked end D fig. 19, which is the north, of a magnetic bar just under them, and the wires will immediately repel each other, as shown in fig. 18; and this divergency will increase to a certain limit; according as the magnet is brought nearer, and vice versa. The reason of this phenomenon is, that by the action of the north magnetic pole D, both the extremities B, B, of the wires, acquire the same, viz. the south polarity; consequently they repel each other; and the extremities, A, A, acquire the north polarity, in consequence of which they also repel each other.

If instead of the north pole D, you present the south pole of the magnetic bar, the repulsion will take place as before; but now the extremities B, B, acquire the north, and the extremities A, A, acquire the south polarity.

On removing the magnet, the wires, if of soft iron, will soon collapse, having lost all their magnetic power; but if steel wires, or common sewing needles be used, they will continue to repel each other after the removal of the magnet; the magnetic power being retained by steel.

Ex. 3. Lay a sheet of paper flat upon a table, strew some iron filings upon the paper, place a small magnet among them; then give a few gentle knocks to the table, so as to shake the filings, and you will find that they dispose themselves about the magnet NS, as shown in fig. 20; the particles of iron clinging to one another, and forming themselves into lines, which at the very poles N, S, are in the same direction with the axis of the magnet; a little sideway of the poles they begin to bend, and then they form complete arches, reaching from some point in the northern half of the magnet, to some other point in the southern half.

Ex. 4. Place a magnetic bar AB, fig. 21, so that one of its poles may project a short way beyond the table, and apply an iron weight C to it; then take another magnetic bar, DE, like the former, and bring it parallel to, and just over the other, at a little distance, and with the contrary poles towards each other; in consequence of which the attraction of B will be diminished, and the iron C, if sufficiently heavy, will drop off, the magnet AB being then only able to support a smaller piece of iron. By bringing the magnets still nearer to each other, the attraction of B will be diminished still farther; and, when the two magnets come quite into contact (provided they are equal in power), the attraction between B and C will vanish entirely; but if the experiment be repeated with this difference, viz. that the homologous poles of the magnets be brought towards each other, then the attraction between B and C, instead of being diminished, will be increased.

MAGNITUDE, whatever is made up of parts locally extended, or that has several dimensions; as a line, surface, solid, &c. The apparent magnitude of a body is that measured by the visual angle, formed by rays drawn from the extremes to the centre of the eye; so that whatever things are seen under the same or equal angles, appear equal; and vice versa.

MAGNOLIA, a genus of the polygynia order, belonging to the polyandria class of plants; and in the natural method ranking under the 52nd order, coadnatæ. The calyx is triphyllous; there are nine petals; the capsules bivalved and imbricated; the seeds pendulous, and in the form of a berry. There are seven species: the principal are,

1. The glauca, or small magnolia, a native of Virginia, Carolina, and other parts of North America. In moist places it rises from seven or eight to fifteen or sixteen feet high, with a slender stem. The wood is white and spongy, the flowers are produced at the extremities of the branches, are white, composed of six concave petals, and have an agreeable scent. 2. The grandiflora, or great magnola, is a native of Florida and South Carolina. It rises, to the height of eighty feet or more, with a straight trunk upwards of two feet diameter, having a regular head. The leaves resemble those of the laurel, but are larger, and continue green throughout the year. The flowers are produced at the ends of the branches, and are of a purplish-white colour. 3. The tripetala, or umbrella tree, is a native of Carolina; it rises, with a slender trunk, to the height of sixteen ort wenty feet; the wood is soft and spongy; the leaves remarkably large, and pro-

duced in horizontal circles, somewhat resembling an umbrella, whence the inhabitants of those countries have given it this name. The flowers are composed of ten or eleven white petals, that hang down without any order. The leaves drop off at the beginning of winter. 4. The acuminata, with oval, spear-shaped, pointed leaves, is a native of the inland parts of North America. The leaves are near eight inches long, and five broad, ending in a point. The flowers come out early in the spring, and are composed of twelve white petals; the wood is of a fine grain. and an orange colour.

MAHERNIA, a genus of the class and order pentandria pentagynia. The cal. is 5-toothed: petals 5; nec. 5 obcordate, placed under the filaments; caps. 5-celled. There are three species, shrubs of the Cape. The incisa is a beautiful little shrub for the greenhouse.

MAIL. or *coat of* MAIL, a piece of defensive armour for the body, made of small iron rings, interwoven in the manner of a net.

MAIM, MAIHEM, or MAYHEM, in law. It is enacted, by the statute of 22 and 23 Car. II. that if any person from malice aforethought, shall disable any limb or member of any of the king's subjects with an intent to disfigure them, the offender, with his aides and abettors, shall be guilty of felony without benefit of clergy; though no such attainder shall corrupt the blood, or occasion forfeiture of lands, &c.

If a man attack another with an intent to murder him, and he does not murder the man, but only maim him, the offence is nevertheless within the statute 22 and 23 Car. II. c. I, usually called the Coventry act. 1 Haw. 112.

MAINPRISE, the taking or receiving a man into friendly custody, that otherwise is or might be committed to prison, upon security given for his forthcoming at a day assigned. See BAIL BOND.

MAINTENANCE, is the unlawful taking in hand, or upholding; of a cause or person: this offence bears a near resemblance to barratry, being a person's intermeddling in the suit of another, by maintaining or assisting him with money, or otherwise, to prosecute or defend it. A man may maintain the suit of his near kinsman, servant, or poor neighbour, out of charity or compassion, without being guilty of maintenance. By the common law, persons guilty of maintenance may be prosecuted by indictment, and be fined and imprisoned, or be compelled to make satisfaction by action, &c.; and a court of record may commit a man for an act of maintenance done in the face of the court. 1 Inst. 368.

MAJOR, in logic, the first proposition of a syllogism.

MAJOR and MINOR, in music, signify imperfect concords, which differ from each other by a semitone minor.

MALACHODENDRUM, a genus of the class and order monadelphia polyandria. The cal. is simple; germ. pear-shaped, pentagonal; styles, 5; caps. 5, one-seeded: one species, of no note.

MALACHOA, a genus of the class and order monadelphia polyandria. The cal. is common, 3-leaved, many-flowered, longer; arils 5, 1-seeded. There are five species, herbs of the West Indies.

MALACHITE, green carbonat of copper. This ore is often amorphous, but often crystallized in long slender needles.

Colour green. Brittle. Specific gravity 3·571 to 3.653. Effervesces with nitric acid, and gives a blue colour to ammonia. Before the blowpipe it decripitates and blackens, but does not melt. Tinges borax yellowish green. Tinges flame green.

Variety 1. Fibrous malachite.—Texture fibrous. Opaque when amorphous; when crystallized it is partly transparent is 2. Colour generally grass-green.

Variety 2. Compact malachite.—Texture compact. Opaque. Colour varies from the dark emerald-green to blackish green.

A specimen of malachite from Siberia, analysed by Klaproth, contained

58.0	copper
18.0	carbonic acid
12.5	oxygen
11.5	water
100.	

This species is sometimes mixed with clay, chalk, and gypsum, in various proportions; it it then known by the name of common mountain-green. Its colour is verdigris-green. Brittle. Texture earthy. Effervesces feebly with acids. Before the blowpipe it exhibits the same phenomena as malachite.

A comparison of the analysis of Klaproth with that of Pelletier seems to prove that malachite contains copper oxidized to a greater degree than blue copper ore.

MALACOLITE. This mineral was first observed in Sweden in the silver-mine of Sahla in Westermania; afterwards in Norway. Colour green. Found massive and crystallized in six-sided prisms, having two opposite edges truncated. Waxy. Texture lamellated. Feel soft. Specific gravity 3.2307. Melts before the blowpipe into a porous glass. According to the analysis of Vauquelin, it is composed of

53	silica
20	lime
19	magnesia
3	alumina
4	oxide of iron and manganese
99	

MALATS, in chemistry. This genus of salts is almost unknown, owing chiefly to the difficulty of procuring pure malic acid. The followiug are the only facts hitherto ascertained.

Malat of potass.
Malat of soda.
Malat of Ammonia.

These salts were formed by Scheele. They are deliquescent and very soluble.

Malat of Barytes. When malic acid is dropt into barytes water, a white powder precipitates, which is malat of barytes. According to Scheele, the properties of this salt resemble those of malat of lime.

Malat of strontian. Malic acid occasions no precipitate in strontian water. Hence it follows, that malat of strontian is more soluble than malat of barytes.

When malic acid is neutralized with lime, it forms a salt scarcely soluble in water, which may be obtained in crystals, by allowing the supermalat of lime to evaporate spontaneously. Crystals of natural malat are formed in the solution. But this acid has a strong tendency to

combine in excess with lime, and to form a supermalat of lime. This salt is formed when carbonat of lime is thrown into malic acid, or into any liquid containing it. This supersalt exists in various vegetables, especially the supervivum tectorum, and some of the sedums.

Supermalat of lime has an acid taste. It yields a precipitate with alkalies, sulphuric acid, and oxalic acid. Lime-water saturates the excess of acid, and throws down a precipitate of malt of lime. When the supermalet of lime is evaporated to dryness, it assumes exactly the appearance of gum arabic; and if it has been spread thin upon the nail or wood, it forms a varnish. It is not so soluble in water as gum arabic, and the taste readily distinguishes the two. Supermalet of lime is insoluble in alcohol.

Malet of magnesia, this salt is very soluble in water, and when exposed to the air deliquesces.

Malat of alumina. This salt is almost insoluble in water. Of course it precipitates when malic acid is dropt into a solution containing alumina. Mr. Chenevix has proposed this acid to separate alumina from magnesia; which earths, as it is well known, have a strong affinity for each other.

MALAXIS, a genus of the class and order gynandria diandria. The nec. is one-leaved, concave, coruate; acumina, pale, bifid in front. There are two species, bulbs of Jamaica.

MALIC *acid*, obtained from the juice of apples; it is also extracted from the juice of commom house-leek, where it exists combined with lime. The process is as follows: To the juice of the house-leek add acetat of lead as long as any precipitate takes place. Wash the precipitate, and decompose it by means of diluted sulphuric acid in the manner directed by Scheele.

Malic acid may be formed also by the action of nitric acid of sugar. If nitric acid is distilled with an equal quantity of sugar, till the mixture assumes a brown colour (which is a sign that all the nitric acid has been abstracted from it), this substance will be found of an acid taste; and after all the oxalic acid which may have been formed is separated by lime-water, there remains another acid, which may be obtained by the following process: saturate it with lime, and filtre the solution: then pour upon it a quantity of alcohol, and a coagulation takes place. This coagulation is the acid combined with lime. Separate it by filtration, and edulcorate it with fresh alcohol; then dissolve it in distilled water, and pour in acetat of lead till no more precipitation ensues. The precipitate is the acid combined with lead, from which it may be separated by diluted sulphuric acid.

Malic acid, thus obtained, is a liquid of a reddish-brown colour and a very acid taste. When evaporated it becomes thick and viscid like a mucilage or syrup, but it does not crystallize. When exposed to a dry atmosphere in thin layers, it dries altogether, and assumes the appearance of varnish. When heated in the open fire it becomes black, swells up, exhales an acrid fume, and leaves behind it a very voluminous coal. When distilled, the products are an acid water; a little carbureted hydrogen gas, and a large proportion of carbonic acid. It is very soluble in water. It gradually decomposes spontaneously, by undergoing a kind of fermentation in the vessels in which it is kept. Sulphuric acid chars it, and nitric acid converts it into ozalic acid. Hence it is evident that it is composed of oxygen, hydrogen, and carbon, though the proportion of these substances have not been ascertained.

Malic acid combines with alkalies, earths, and metallic oxides, and forms salts known by the name of Malats, which see.

Its affinities have not yet been ascertained.

This acid bears a strong resemblance to the nitric, but differs from it in the following particulars: 1. The citric acid shoots into fine crystals, but this acid does not crystallize. 2. The salt formed from the citric acid with lime is almost insoluble in boiling water; whereas, the salt made with malic acid and the same basis is readily soluble by boiling water. 3. Malic acid precipitates mercury, lead, and silver, from the nitrous acid, and also the solution of gold when diluted with water; whereas citric acid does not alter any of these solutions. 4. Malic acid seems to have a less affinity than citric acid for lime; for when a solution of lime in the former is boiled a minute, with a salt formed from volatile alkali and citric acid, a decomposition takes place, and the latter acid combines with the lime, and is precipitated.

MALLEABLE, a property of metals, whereby they are capable of being extended under the hammer.

MALOPE, a genus of the class and order monadelphia polyandria. The calyx is double, outer three-leaved; arils glomerate, one-seeded. There are two species, herbs of Tuscany, &c.

MALPIGHIA, *Barbadoes cherry*, a genus of the trigynia order, in the decandria class of plants, and in the natural method ranking under the 23d order, trihilatæ. The calyx is pentaphylloas, with melliferous pores on the outside at the base. There are five petals, roundish and unguiculated; the berry unilocular and trispermous. There are 18 species, all of them shrubby evergreens of the warm parts of America, rising with brancby stems from 8 or 10 to 15 or 20 feet high, ornamented with oval and lanceolate entire leaves, and large pentapetalous flowers, succeeded by red, cherry-shaped, eatable berries, of an acid and palatable flavour; and which in the West Indies, where they grow naturally, are used instead of cherries. Three of the species are reared in English gardens, and make a fine variety in the stove. They retain their leaves all the year round; and begin to flower about the end of autumn, continuing in constant succession till the spring: after which they frequently produce and ripen their fruit, which commonly equals the size of a small cherry. The flowers are of a pale-red or purple colour.

MALT, is barley prepared, to fit it for making a potable liquor called beer, or ale, by stopping it short at the beginning of vegetation.

In making malt from barley, the usual method is to steep the grain in a sufficient quantity of water, for two or three days, till it swells, becomes plump, somewhat tender, and tinges the water of a bright-brown, or reddish colour. Then this water being drained away, the barley is removed from the steeping cistern to the floor, where it is thrown into what is called the wet couch; that is, an even heap, rising to the height of about two feet. In this wet couch the capital part of the operation is performed; for here the barley spontaneously heats, and begins to grow, shooting out first the radicle; and if suf-

fered to continue, then the plume, spire, or blade. But the process is to be stopped short at the eruption of the radicle, otherwise the malt would be spoiled. In order to stop it, they spread the wet couch thin over a large floor, and keep turning it once in four or five hours, for the space of two days, laying it somewhat thicker each time. After this, it is again thrown into a large heap, and there suffered to grow sensibly hot to the hand, as it usually will in 20 or 30 hours time; then being spread again, and cooled, it is thrown upon the kiln, to be dried crisp without scorching.

MALTA, KNIGHTS OF, otherwise called *hospitalers of St. John of Jerusalem*, a religious military order, whose residence is in the island of Malta. The order consists of three estates, the knights, chaplains, and servants at arms: there are also priests who officiate in the churches, friar-servants who assist at the offices, and donnes or demicrosses; but these are not reckoned constituent parts of the body: the government of the order is mixt, being partly monarchical, and partly aristocratical: the grand master is sovereign. The knights formerly consisted of eight different languages, but now only seven, the English having withdrawn themselves. None are admitted into this order but such as are of noble birth: the knights are of two sorts, those who have a right to be candidates for the dignity of grand-master, called grand-crosses, and those who are only knights assistants: they never marry. The knights are received into this order, either by undergoing the trials prescribed by statutes, or by dispensation.

MALTHA, in antiquity, a kind of cement of which there were two sorts, native and factitious; one of the latter sort, much in use, consisted of pitch, wax, plaister, and grease. Another kind used by the Romans in their aqueducts, was made of lime slacked in wine, incorporated with melted pitch, and fresh figs. Natural maltha is a kind of bitumen, with which the Asiatics plaister their walls; and which being once set on fire, water makes it burn more fiercely. See BITUMEN.

MALVA, the *mallow*, a genus of the polyandria order, in the monadelphia class of plants, and in the natural method ranking under the 37th order, columniferæ. The calyx is double; the exterior one triphyllous; the arilli numerous and monospermous. There are 34 species, consisting of herbaceous perennials, biennials, and annuals, for medical, economical, and ornamental uses.

The leaves of the common mallow are reckoned the first of the four emollient herbs: they were formerly in some esteem as food; at present decoctions of them are sometimes employed in dysenteries, heat, and sharpness of urine, and in general for obtunding acrimonious humours: their principal use is in emollient glysters, cataplasms, and fomentations. The leaves enter the officinal decoction for glysters, and a conserve is prepared from the flowers. Several pieces of malva, macerated like hemp, afford a thread superior to hemp for spinning, and which is said to make more beautiful cloths and stuffs than even flax. These species are the crispa, Peruviana, and Maurisiana. From the former, which affords stronger and longer fibres, cords and twine have also been made. From the malvæ likewise a new sort of paper has been fabricated by M. de l'Isle.

MAMMÆ, in anatomy, the breasts of a female.

MAMMALIA, in natural history, the first class of animals in the Linnæan system, divided into seven orders. See ZOOLOGY.

MAMMEA, *mammee-tree*, a genus of the monogynia order, in the polyandria class of plants, and in the natural method ranking with those of which the order is doubtful. The corolla is tetrapetalous; the calyx diphyllous; the berry very large and tetraspermous. There is one species, a large evergreen tree of the hot parts of America and Asia, adorned with large, oval, oblong, stiff leaves, and large quadripetalous flowers, succeeded by large, round, eatable fruit, of a most exquisitely rich flavour. They are propagated by seed, which in cold countries is to be sowed in small pots of light earth, and kept in the stove.

MAMMILLARY. See ANATOMY.

MANATI, in zoology, See TRICHECUS.

MANCA, was a square piece of gold coin, commonly valued at 30 pence; and mancusa was as much as a mark of silver, having its name from manu cusa, being coined with the hand (Leg. Canut.). But the manca and mancusa were not always of that value: for sometimes the former was valued at six shillings, and the latter, as used by the English Saxons, was equal in value to our half-crown.

MANDAMUS, is a writ issuing in the king's bench, and directed to any person, corporation, or inferior court of judicature, commanding to some particular thing therein specified, as appertaining to their office and duty.

A writ of mandamus is a high prerogative writ, of a most extensive remedial nature, and may be issued in some cases where the injured party has also another more tedious method of redress, as in the case of admission or restitution to an office; but it issues in all cases where the party has a right to have any thing done, and has no other specific means of compelling its performance. 3 Black. 100.

And this general jurisdiction and superintendance of the king's bench over all inferior courts to restrain them within their bounds, and to compel them to execute their jurisdiction, whether such jurisdiction arises from a modern charter, subsists by custom, or is created by act of parliament, yet being in subsidium justitiæ, has of late been exercised in a variety of instances.

Mandamus was also a writ that lay after the year and a day (where, in the mean time, the writ called diem clausit extremum had not been sent out) to the escheator, commanding him to inquire of what lands holden by knight-service the tenant died seized, &c. F. N. B. 561.

Mandamus was also a writ to charge the sheriff to take into the king's hands all the lands and tenements of the king's widow, who, against her oath formerly given, marries without the king's consent. Reg. 295.

MANETTIA, a genus of the class and order tetrandria monogynia. The calyx is eight leaved; corolla four-cleft; capsule inferior, two-valved, one-celled; seeds imbricate, unilocular. There are three species, shrubs of of the West Indies.

MANGANESE. I. The dark-grey or brown mineral called manganese has been long known and used in the manufacture of glass. A mine of it was discovered in England by Mr. Boyle. A few experiments were made upon this mineral by Glauber in 1656, and by

Waitz in 1795; but chemists in general seem to have paid but very little attention to it. The greater number of mineralogists, though much puzzled what to make of it, agreed in placing it among iron ores: but Pott, who published the first chemical examination of this mineral in 1740, having ascertained that it often contains scarcely any iron, Cronstedt, in his System of Mineralogy, which appeared in 1758, assigned it a place of its own, on the supposition that it consisted chiefly of a peculiar earth. Rinman examined it anew in 1765; and in the year 1770 Kaim published at Vienna a set of experiments, in order to prove that a peculiar metal might be extracted from it. The same idea had struck Bergman about the same time, and induced him to request of Scheele, in 1771, to undertake an examination of manganese. Scheele's dissertation on it, which appeared in 1774, is a masterpiece of analysis, and contains some of the most important discoveries of modern chemistry. Bergman himself published a dissertation on it the same year; in which he demonstrates that the mineral, then called manganese, is a metallic oxide. He accordingly made several attempts to reduce it, but without success; the whole mass either assuming the form of scoriæ, or yielding only small separate globules attracted by the magnet. This difficulty of fusion led him to suspect that the metal he was in quest of bore a strong analogy to platinum. In the mean time Dr. Gahn, who was making experiments on the same mineral, actually succeeded in reducing it by the following process: he lined a crucible with charcoal-powder moistened with water, put into it some of the mineral formed into a ball by means of oil, then filled up the crucible with charcoal-powder, luted another crucible over it, and exposed the whole for about an hour to a very intense heat. At the bottom of the crucible was found a metallic button, or rather a number of small metallic globules, equal in weight to one-third of the mineral employed. It is easy to see by what means this reduction was accomplished. The charcoal attracted the oxygen from the oxide, and the metal remained behind. The metal obtained, which is called manganese, was farther examined by Ilseman in 1782, Hielm in 1785, and Bindheim in 1789.

Manganese, when pure, is of a greyish-white colour, and has a good deal of brilliancy. Its texture is granular. It has neither taste nor smell. Its hardness is equal to that of iron. Its specific gravity is 7.000. It is very brittle; of course it can neither be hammered, nor drawn out into wire. Its tenacity is unknown. It requires, according to Morveau, the temperature of 160° Wedgewood to melt it; so that plantinum excepted, it is the most infusible of all the metals. When reduced to powder it is attracted by the magnet, owing probably to a small portion of iron from which it can with difficulty be parted.

II. Manganese, when exposed to the air, attracts oxygen more rapidly than any other body, phosphorus excepted. It loses its lustre almost instantly, becomes grey, violet, brown, and at last black. These changes take place still more rapidly if the metal is heated in an open vessel.

This metal seems capable of combining with three different proportions of oxygen, and of forming three different oxides, the white, the red, and the black.

The protoxide or white oxide may be obtained by dissolving the black oxide of manganese in nitric acid by adding a little sugar. The sugar attracts oxygen from the black oxide, and converts it into the white, which is dissolved by the acid. Into the solution pour a quantity of potass; the protoxide precipitates in the form of a white powder. It is composed, according to Bergman, of 80 parts of manganese and 20 of oxygen. When exposed to the air it soon attracts oxygen, and is converted into the black oxide.

The deutoxide or red oxide may be obtained by dissolving the black oxide in sulphuric acid, without the addition of any combustible substance. When black oxide of maganese, made into a paste with sulphuric acid, is heated in a retort, a great quantity of oxygen gas comes over, while the oxide, thus deprived of part of its oxygen, dissolves in the acid. Distil to dryness, and pour water upon the residuum, and pass it through a filtre. A red-coloured solution is obtained, consisting of the sulphat of manganese dissolved in water. On the addition of an alkali a red substance precipitates, which is the red oxide of manganese. According to Bergman it is composed of 74 parts of manganese and 26 of oxygen. This oxide likewise attracts oxygen when exposed to the atmosphere, and is converted into the black oxide.

The peroxide of black oxide of manganese exists abundantly in nature; indeed it is almost always in this state that manganese is found. It was to the black oxide that the appellation manganese itself was originally applied. It may be formed very soon by exposing the metal to the air. This oxide, according to Fourcroy, is composed of 60 parts of manganese and 40 of oxygen. When heated to redness in an earthen retort it gives out abundance of oxygen gas, which may be collected in proper vessels. By this operation it is reduced nearly to the state of red oxide. If it is exposed to the air, and moistened occasionally, it absorbs a new dose of oxygen; and thus the same process may again be repeated. No oxygen gas can be obtained from the white oxide: a proof that its oxygen is retained by a stronger affinity than the additional dose of oxygen which constitutes the black oxide. Seguin has observed, that in some cases the black oxide of manganese emits, before it becomes red, a quantity of azotic gas. When long exposed to a strong heat it assumes a green colour. In that state it is whitened by sulphuric acid, but not dissolved. A very violent heat fuses this oxide, and converts it into a green-coloured glass.

III. Manganese does not combine with hydrogen. When dissolved in sulphuric acid a black spongy mass of carburet of iron is left behind. Hence it has been supposed capable of combining with carbon; but it is more probable that the carbon is combined with the iron, which is almost always present in manganese. It seems pretty clear, however, that carburet of iron is capable of combining with this metal, and that it always forms a part of steel.

Bergman did not succeed in his attempt to combine manganese with sulphur; but he formed a sulphureted oxide of manganese, by combining eight parts of the black oxide with three parts of sulphur. It is of a green colour, and gives out sulphureted hydrogen gas when acted on by acids. It cannot be doubted, however, that

the sulphur is capable of combining with manganese; for Proust has found native sulphuret of manganese in that ore of tellurium which is known by the name of gold ore of Nagyag.

Phosphorus may be combined with manganese by melting together equal parts of the metal and of phosphoric glass; or by dropping phosphorus upon red-hot manganese. The phosphuret of manganese is of a white colour, brittle, granulated, disposed to crystalize, not altered by exposure to the air, and more fusible than manganese. When heated the phosphorus burns, and the metal is oxidized.

IV. Manganese does not combine with either of the simple combustibles.

V. Manganese combines with many of the metals, and forms with them alloys which have been but very imperfectly examined.

It unites readily with copper. The compound, according ty Bergman, is very malleable, its colour is red, and it sometimes becomes green by age. Gmelin made a number of experiments to see whether this alloy could be formed by fusing the black oxide of manganese along with copper. He partly succeeded, and proposed to substitute this alloy instead of the alloy of copper and arsenic, which is used in the arts.

It combines readily with iron; indeed it has scarcely been found quite free from some mixture of that metal. Manganese gives iron a white colour, and renders it brittle. It combines also with tin, but scarcely with zinc.

It does not combine with mercury nor with bismuth. Gmelin found that manganese cannot be alloyed with bismuth without great difficulty; and that it unites to antimony very imperfectly. Chemists have not attempted to combine it with gold, plantinum, silver, nickel, nor cobalt.

VI. The affinities of manganese, and of its white and red oxides, are, according to Bergman, as follows:

Manganese.	*Oxide of manganese.*
Copper,	Oxalic acid,
Iron,	Citric,
Gold,	Phosphoric,
Silver,	Tartaric,
Tin,	Fluoric,
	Muriatic,
	Sulphuric,
	Nitric,
	Saclactic,
	Succinic,
	Tartaric,
	Lactic,
	Acetic,
	Prussic,
	Carbonic.

MANGIFERA, the *mango-tree*, a genus of the monogynia order, in the pentandria class of plants, and in the natural method ranking with those of which the order is doubtful. The corolla is pentapetalous; the plum kidney-shaped. There are three species, the principal of which is a native of many parts of the East Indies, whence it has been transplanted to Brazil, and other warm parts of America. It grows to a large size; the wood is brittle; the bark rough when old; the leaves are seven or eight inches long, and more than two inches broad. The flowers are produced in loose panicles at the ends of the branches, and are succeeded by large oblong kidney-shaped plums. This fruit, when fully ripe, is greatly esteemed in the countries where it grows; but in Europe they have only the unripe fruit brought over in pickle. All attempts to propagate the plant have hitherto proved ineffectual; and Mr. Millar is of opinion that the stones will not vegetate unless they are planted soon after they are ripe.

MANIA. See MEDICINE.

MANICHEES, in church history, a sect of christian heretics in the third century, the followers of Manes, who made his appearance in the reign of the emperor Probus; pretending to be the Comforter, whom our saviour promised to send into the world. He taught that there are two principles, or gods, coeternal and independant on each other; the one the author of all evil, and the other of all good; a doctrine which he borrowed from the Persian magi. He held that our souls were made by the good principle, and our bodies by the evil one: and that the souls of his followers passed through the elements to the moon, and from thence to the sun, where being purified, they then went to God, and became united with his essence; but as for the souls of other men, they either went to hell, or were united to other bodies.

MANILLE, in commerce, a large brass ring, in the form of a bracelet, either plain or engraven, flat or round. Manilles are the principal commodities which the Europeans carry to the coast of Africa, and exchange with the natives for slaves. These people wear them as ornaments on the small of the leg, and on the thick part of the arm above the elbow. The great men wear the manilles of gold and silver, but these are made in the country by the natives themselves.

MANIPULUS, in Roman antiquity, a body of infantry, consisting of 200 men, and constituting the third part of a cohort. See COHORT.

MANIS, a genus of quadrupeds of the order of bruta. The generic character is, teeth none; tongue cylindric and extensile; mouth narrowed into a snout; body covered with scales. The genus manis presents an appearance not less extraordinary than that of dasypus or armadillo; being covered on every part, except on the belly, with extremely strong and large horney scales, constituting a suit of armour still more powerful than in the following genus, and capable of defending the animals, when rolled up from the assaults of the most ferocious enemies. This external covering, together with the uncommon length of the body and tail, gives an aspect so much resembling that of a lizard, that these creatures are commonly known by the title of scaly lizards: they may be allowed, however, in a general view of the animal kingdom, to form a kind of shade or link of approximation between the proper viviparous quadrupeds and the lizards.

They are animals of a harmless nature, and feed in the same manner as the ant-eaters, by thrusting out their very long tongue into the nests of ants and other insects, and swallowing their prey by suddenly retracting it, having no teeth, and differing from the ant-eaters in scarcely any other circumstance than that of their

scaly integment. They are found in India and the Indian islands.

1. Manis tetradactyla, long-tailed manis. This animal, known in India by the name of the phatagen; is of a very long and slender form: the head is small; the snout narrow; the whole body, except beneath, covered with broad, but sharp-pointed, scales, which are striated through their whole length: the tail is more than twice the length of the body, and tapers gradually to the tip. The legs are very short, scaled like the body, and on each of the feet are four claws, of which those on the fore feet are stronger than those of the hind. The colour of the whole animal is an uniform deep-brown, with a cast of yellowish, and with a glossy or polished surface. The manis tetradactyla grows to the length of five feet, measuring from the tip of the nose to the extremity of the tail.

2. Manis pentadactyla, short-tailed manis, differs from the former, in being of a much thicker and shorter form; the tail, in particular, differs greatly in proportion from that of the preceeding, being not so long as the body, very thick at the base, and thence gradually tapering, but terminating very obtusely. The head is small as in the former; the ears small and rounded; the feet furnished with five toes each, of which those on the fore feet are extremely strong, except the exterior one, which is much smaller than the rest. The whole animal is covered with most extremely thick, strong, and large scales, which in the full-grown specimens are perfectly smooth, but in those which are smaller are slightly striated about half way from the base. Sometimes a few bristles appear between the scales, but in others this is not observable. The scales differ in shape from those of the preceeding, being much wider and larger in proportion to the body and tail. The colour of the whole animal is a very pale yellow brown, and the surface is glossy, as in the former species. In India it is called the pongoelling. In the neighbourhood of Bengal it is named vajracite, or the thunderbolt reptile, from the excessive hardness of the scales, which are said to be capable even of striking fire like a flint. It is said to walk slowly; but, when pursued, rolls itself up, and is then so securely armed, that even a leopard attacks it in vain. It is also said sometimes to destroy the elephant, by twisting itself round the trunk, and thus compressing that tender and sensible organ with its hard scales. We are told in the Asiatic Researches that the Malabar name of this animal is alungu; and that the natives of Bahar call it bajar-cit, or the stone vermin; and in the stomach of the one examined and described in the above work was found about a teacupful of small stones, which it is supposed to have swallowed for the purpose of facilitating digestion. It was only 34 inches long from the nose to the end of the tail; and a young one was found in it.

Specimens of the manis pentadactyla have sometimes been seen of the length of six feet from the nose to the tip of the tail. See Pl. LXXXIV. Nat. Hist. fig. 258.

MANNA, in natural history. This substance exudes from the fraxinus ornus, in the months of June and July, from the stem and branches. It is at first liquid, but gradually becomes solid. It is collected in Sicily and the southern parts of Italy, It is in form of oblong globules of a whitish-yellow colour, and somewhat transparent. It is very light. Its taste is sweet, and it leaves a nauseous bitter impression in the mouth. Its properties have not been examined by chemists. It acts as a mild cathartic. See Materia Medica.

MANOMETER, or Manoscope, an instrument to show or measure the alterations in the rarity or density of the air. The manometer differs from the barometer in this, that the latter only serves to measure the weight of the atmosphere; or of the column of air over it, but the former of the density of air in which it is found; which density depends not only on the weight of the atmosphere, but also on the action of heat and cold, &c. Authors, however, generally confounded the two together: and Mr. Boyle himself gives us a very good manometer of his contrivance, under the name of statical barometer, consisting of a bubble of thin glass, about the size of an orange, which, being counterpoised when the air was in a mean state of density, by means of a nice pair of scales. sunk when the atmosphere became lighter, and rose as it grew heavier. See Meterology.

MANOR, was a district of ground held by lords or great personages, who kept in their own hands so much land as was necessary for the use of their families, which were called terræ dominicales, or demesne lands, being occupied by the lord, or dominus manerii, and his servants. The other lands they distributed among their tenants, which the tenants held under divers services. The residue of the manor being uncultivated was termed the lord's waste, and served for common of pasture to the lord and his tenants. All manors existing at this day must have existed as early as king Edward the First. 2 Black. 90. See Court Baron.

MANSLAUGHTER, is unlawfully killing a man without any malice prepense, or forethought. The English law very humbly makes a distinction between a hasty and deliberate act: as when two persons on a sudden quarrel, fight, and one is killed; yet as it is done in a sudden heat of passion, and not with any premeditated malice, it is manslaughter, and not murder. See Murder.

This crime may be either voluntary, as on a sudden loss of temper; as if a man is greatly provoked, and kills the aggressor, it is manslaughter; but if it appears that there was a sufficient cooling time for the heat of anger to subside, this shows deliberate revenge, and amounts to murder. Or it may be involuntarily; but in the commission of some unlawful act; in which latter respect it differs from homicide per infortunium: as if one shoots off a gun in a highway, and where people often meet, and kills a man: or if he is shooting at game, and is not qualified or licensed, and kills another, it is manslaughter. And, in general, when an involuntary killing happens, in consequence of an unlawful act, it will be murder or manslaughter, according to the act which occasioned it.

It is evident from the nature of this crime that there can be no accessaries, because it must be done without premeditation; but when two men once fell out, and immediately fought, and the sword of one was broken, and his friend lent him another, with which he killed his antagonist, it was made manslaughter in both. Again: there were two men in a room quarreling; a brother of one of them standing at the door, who cold not get in, cried out to his brother to make him sure, and the bro-

ther killed his antagonist: it was likewise manslaughter in both.

But if any person shall stab another, not having his weapon drawn, or not strucken first, so that he dies within six months, although it be not of malice aforethought, it is felony without benefit of clergy.

This crime, though felony, is within benefit of clergy; and the offender shall be burnt in the hand, and forfeit all his goods and chattels; but by stat. 19 Geo. III. c. 74, it is made lawful for the court to commute this punishment for a moderate fine and imprisonment.

MANTELETS, in the art of war, a kind of moveable parapets, made of planks about three inches thick, nailed one over another, to the height of almost six feet, generally cased with tin, and set upon little wheels, so that in a siege they may be driven before the pioneers, and serve as blinds to shelter them from the enemy's small shot.

MANTIS, a genus of insects of the order hemiptera. The generic character is, head unsteady, armed with jaws, and furnished with palpi or feelers; antennæ setaceous; thorax linear; wings four, membranaceous, convoluted, the lower pair pleated; fore legs, in most species, compressed, serrated beneath, and armed with a single claw and a setaceous, lateral, jointed foot; hind legs smooth, formed for walking. This is one of the most singular genera in the whole class of insects; and imagination itself can hardly conceive shapes more strange than those exhibited by some particular species. See Plate LXXXIV. Nat. Hist. fig. 259.

The chief European kind is the mantis oratoria of Linnæus, or camel cricket, as it is often called. This insect, which is a stranger to the British isles, is found in most of the warmer parts of Europe, and is entirely of a beautiful green colour. It is nearly three inches in length, of a slender shape, and in its general sitting posture is observed to hold up the two fore legs, slightly bent, as if in an attitude of prayer: for this reason the superstition of the vulgar has conferred upon it the reputation of a sacred animal; and a popular notion has often prevailed, that a child or traveller having lost his way would be safely directed by observing the quarter to which the animal pointed when taken into the hand. In its real disposition it is very far from sanctity, preying with great rapacity on any of the smaller insects which fall in its way, and for which it lies in wait with anxious assiduity in the posture at first mentioned, seizing them with a sudden spring when within its reach, and devouring them. It is also of a very pugnaceous nature; and when kept with others of its own species in a state of captivity, will attack its neighbour with the utmost violence, till one or the other is destroyed in the contest.

Among the Chinese this quarrelsome property in the genus mantis is turned into a similar entertainment with that afforded by fighting cocks and quails.

The mantis precaria is a native of many parts of Africa, and is the supposed idol of the Hottentots, which those superstitious people are reported to hold in the highest veneration, the person on whom the adored insects happens to light being considered as favoured by the distinction of a celestial visitant, and regarded ever after in the light of a saint. This species is of the same general size and shape with the M. oratoria, and is of a beautiful green colour, with the thorax ciliated or spined on each side, and the upper wings each marked in the middle by a semitransparent spot.

Of all the mantes perhaps the most singular in its appearance is the mantes gongylodes of Linnæus, which, from its thin limbs, and the grotesque form of its body, especially in its dried state, seems to resemble the conjunction of several fragments of withered stalks. There are 14 species of this genus.

MANTLE, or MANTLING, in heraldry, that appearance of folding of cloth, flourishing, or drapery, that is in any achievement drawn about the coat of arms.

MANURE, any thing used for fattening and improving land. See HUSBANDRY.

MAP, a plane figure, representing the surface of the earth, or a part thereof.

In maps these three things are essentially requisite. 1. That all places have the same situation and distance from the great circles therein, as on the globe, to show their parallels, longitudes, zones, climates, and other celestial appearances. 2. That their magnitudes be proportionable to their real magnitudes on the globe. 3. That all places have the same situation, bearing, and distance, as on the earth itself.

The true chart performs the first and last of these very exactly, but fails extravagantly in the second; and indeed no kind of projection yet found can exhibit more than two of them at once, by reason of the great difference between a plane and convex superficies.

Maps are not always to be used as they lie before us, for sometimes any part is uppermost; but, generally, the top is the north part, the bottom the south, the right hand the east, and the left hand the west, and marked with these words, or Latin ones of the same import. There is also inscribed a compass, pointing to all the quarters of the world, the north one being marked with a flower deluce.

The degrees of longitude are always numbered at top and bottom, and the degrees of latitude on the east and west sides. In all right-lined and general circular maps, except those of Wright's projection, the degrees of latitude on the sides are of an equal breadth; and in all circular and right-lined maps, except the said Wright's, and the plane charts, the degrees of longitude are unequal.

In general maps the circles corresponding to those in the heavens are inscribed, viz. the equator is expressed by a straight east and west line; and the first meridian, the polar circles, the tropics, and the other meridians and parallels, which are drawn at every five or ten degrees, intersect each other at right angles.

The most natural method of representing a sphere upon a plane seems to be, to divide it into two equal parts, and inscribe each of them in a circle: but as the equator, and the polar axis, which intersects that circle at right angles, and makes one of the meridians, must be supposed equal in length to the half of the periphery (which is not quite two-thirds), it follows of course, that the countries delineated upon, or near, these lines, must be reduced to somewhat less than two-thirds of the size of the countries of equal extent, which lie at the extremity of the circle; and that the lines drawn to measure the latitude, which are parallel to each other, or nearly so, must, in order to preserve as nearly as possible their pro-

portional angles at the points of intersection with the meridians, from segments of circles, of which no two are parallel or concentric.

There may be as many different projections as there are points of view in which a globe can be seen, but geographers have generally chosen those which represent the poles at the top and bottom of the map; these, from the delineation of the lines of latitude and longitude, are called the stereographic, orthographic, and globular projections.

We do not propose to detain the reader with a description of all the projections, some of which are so erroneous (for the purpose of constructing of maps) as to deserve being consigned entirely to oblivion. But as the projection of maps is a pleasing and instructive exercise, and indeed indespensably necessary to the right understanding of geography to students, we shall describe the manner of constructing the map of the world. With regard to the stereographic projection it may be observed, that among the various positions assignable to the eye there are chiefly two that have been adopted, wherein the eye is placed either in the points D, fig. 1, or removed to an infinite distance; and hence this projection is liable to the great error of distorting the form of the countries represented upon it much more than is necessary. The only advantage is, that the lines of latitude and longitude intersect each other at right angles.

This being observed by that excellent astronomer, M. de la Hire, he invented a remedy for the inconvenience, by assigning to the eye a position at the point O, fig. 1, the distance of which from the globe at D is equal to the right sine of 45 degrees; and hence the right line GO, which bisects the quadrant BC, also bisects the radius EC, and produces the similar triangles OFG, and OEI; and thus the other parts of the quadrant BC, and in like manner of the whole semicircle ABC, are represented in the projection nearly proportionable to each other, and to sense perfectly so. The delineation of the earth and sea upon this projection (which, as coming the nearest to a true representation of the globe, is called the globular projection), is equal to the stereographic in point of facility, and vastly superior to it in point of truth.

Geometrical construction of the globular projection.—From the centre C, fig. 2, with any radius, as CB, describe a circle; draw the diameters AB, and 90, 90, at perfect right angles to one another, and divide them into nine equal parts; likewise divide each quadrant into nine equal parts, each of which contains ten degrees; if the scale admits of it, every one of these divisions may be subdivided into degrees: next, to draw the meridians, suppose the meridian 80° W. of Greenwich, we have given the two poles 90, 90, and the point 80 in the equator, or diameter AB; describe a circle to pass through the three given points as follows: with the radius 90 set one foot of the compasses on the point 90, and describe the semicircles XX and ZZ, then remove the compasses to the point 80 on the equator, and describe the arcs 1, 1, and 2, 2; where they intersect the semicircle make the point, as at 1 and 2, and draw lines from 2 through the point 1 till they intersect the diameter BA continued in E: then will E be the centre from whence the meridian 90, 80, 90, must be drawn, and will express the meridian of 80° W. longitude from Greenwich; the same radius will draw the meridian expressing 140° W. longitude, in like manner: draw the next meridian with the radius CB, set one foot of the compasses in the point *d*, and describe the arcs *aa* and *bb*, then draw lines as before, which will give the point D, the centre of 90° W. longitude; so of all the rest.

The parallels of latitude are drawn in the same manner, with this difference, that the semicircles XX and ZZ must be drawn from the points A and B, the extremities of the equator.

In the manner above described, with great labour and exactness, Mr. Arrowsmith, to whom we are indebted for a part of this article, drew all the meridians and parallels of latitude to every degree on two hemispheres, which laid the foundation of his excellent map of the world.

We shall now proceed to show how the same thing may be done mechanically, both with regard to the globular and stereographic projection.

(1) *The Globular Projection of the Sphere on the Plane of a Meridian.*

Draw the circle WNES, fig. 3, draw the two diameters NS and WE at right angles with each other.

Divide the arc of each quadrant into nine equal parts.

Divide the radii also in the same manner into ninety equal parts each.

The diameter NS is the meridian, and the diameter WE is the equator.

The other meridians are arcs of circles, for each of which, as we have seen, there are three given points through which it must pass, and those are the two poles NS, and a division on the semi-diameter WC, viz. either *a*, *b*, *c*, *d*, *e*, *f*, *g*, or *h*. The centres for these arcs will be in the line CE produced; and the centres for those on the other side, will be on the line CW produced.

For the arc	S*a*N.	the radius	*aa* = 90,61	Of the = parts of which the radius contains 90.
—	S*b*N.	—	*bb* = 92,82	
—	S*c*N.	—	*cc* = 97,32	
—	S*d*N.	—	*dd* = 106	
—	S*e*N.	—	*ee* = 121,1	
—	S*f*N.	—	*ff* = 149,7	
—	S*g*N.	—	*gg* = 215,6	
—	S*h*N.	—	*hh* = 410,7	

And for each of the arcs representing the parallels of lat. also there are three given points; viz. one of the divisions *k*, *l*, *m*, *n*, *o*, *p*, *q*, or *r*, upon the meridian SN, and the two corresponding divisions of the circumference. The centres for these arcs will fall on the line SN, produced both ways, and the following table shows the length of the radius of each equal part, in equatorial degrees, as in the former case.

For the arc

80	*r*	80	the radius	*rr* = 18,44	Of the equal parts of which the radius contains 90.
70	*q*	70	—	*qq* = 39,75	
$66\frac{1}{2}$	A.	$66\frac{1}{2}$	—	A. *Arctic* = 48,19	
60	*p*	60	—	*pp* = 65,3	
50	*o*	50	—	*oo* = 97,71	
40	*n*	40	—	*nn* = 143	
30	*m*	30	—	*mm* = 210	
$23\frac{1}{2}$	T.	$23\frac{1}{2}$	—	T. *Tropic* = 281,4	
20	*l*	20	—	*ll* = 337,5	
10	*k*	10	—	*kk* = 703,5	

(2) *The Stereographic Projection of the Sphere on the Plane of a Meridian.*

Draw a circle NESW, fig. 4, and the two diameters of it at right angles with each other.

Divide the arc of each quadrant into nine equal parts.

From the point E, draw dotted lines to each point of division on the arc WN.

The intersections made by this means on the semidiameter CN, mark a line of semitangents, which must also be set off on the other three semidiameters, CS, CW, and CE.

Draw likewise two dotted lines from E to $23\frac{1}{2}^{\circ}$ and $66\frac{1}{2}^{\circ}$ for the tropic and polar arcs, which must also be set off on the semi-diameter CS.

Each point of intersection on CN, and the corresponding divisions on the arcs WN and EN, are the three points through which the arcs of latitude must pass; and their centres will be in the line NS produced.

Take the radius of the same circle for a scale; divide it into nine equal parts, and each of those parts into ten other parts as before.

The following table exhibits the length in those parts of the radius, which must be taken to describe each respective arc.

For the arc

80	*r* 80	the radius	*rr*	= 15,87	Of the equal parts of which the radius contains 90.
70	*s* 70	—	*ss*	= 32,75	
$66\frac{1}{2}$	A. $66\frac{1}{2}$	—	A. *Arctic*	= 39.19	
60	*t* 60	—	*tt*	= 51,96	
50	*v* 50	—	*vv*	= 75,52	
40	*w* 40	—	*ww*	= 107,3	
30	*x* 30	—	*xx*	= 155,9	
$23\frac{1}{2}$	T. $23\frac{1}{2}$	—	T. *Tropic*	= 207	
20	*y* 20	—	*yy*	= 247,3	
10	*z* 10	—	*zz*	= 510,4	

The two polar points N. S. and the semitangents on CE. mark the three given points through which each meridian line must pass.

The following table exhibits the length of each radius to describe the meridian arcs.

For the arc	N*a*S.	the radius	*aa*	= 91,4	Of the = parts of which the radius contains 90.
—	N*b*S.	—	*bb*	= 95,78	
—	N*c*S.	—	*cc*	= 104	
—	N*d*S.	—	*dd*	= 117,5	
—	N*e*S.	—	*ee*	= 140	
—	N*f*S.	—	*ff*	= 180	
—	N*g*S.	—	*gg*	= 263	
—	N*h*S.	—	*hh*	= 518,3	

(3) *The Globular Projection of the Sphere on the Plane of the Equator.*

On the centre P, fig. 5, draw the circle WN ES, to represent the equator.

Draw the two diameters, WE and NS, at right angles with each other.

Divide the arcs of the four quadrants into nine equal parts: each of the parts will be equal to ten degrees.

Number them from N towards P, 10, 20, 30, 40, 50, &c.

On the centre P draw circles passing through those points of division, which will be the circles of latitude.

For the arctic circle, set off $23\frac{1}{2}^{\circ}$ from P towards N; do the same at N towards P, for the tropic circle.

Through each of those points draw an obscure circle.

Draw diameters from the divisions on one half of the circumference to the corresponding divisions on the opposite one, to represent the meridians, and this will complete the projection.

(4) *The Stereographic Projection of the Sphere on the Plane of the Equator.*

Draw the circle N, W, S, E, fig. 6, and the two diameters at right angles with each other.

Divide the arcs of each of the four quadrants into nine equal parts; subdivide each of those parts into 10 degrees; number those degrees 10, 20, 30, &c.

Draw diameters from the divisions on one side of the circumference to the corresponding divisions on the other, which will represent the meridians.

For the parallels of latitude, project a line of semitangents as directed in the 2d case.

On the centre P describe circles passing through the semitangents, which will complete the diagram.

Note. The foregoing methods of projecting the sphere are the best. There is another method sometimes used, viz. the projection on the plane of the horizon when any assumed place is considered as the centre; but as this method is rarely used, it need not be elucidated.

The orthographic projection is in fact so erroneous, that it ought to be entirely rejected for that purpose, and applied only to dialling.

The gnomonical projection is only applicable to dialling.

We shall now point out the advantage and disadvantage of Mercator's projection.

A method has been found to obviate some of the difficulties attending all the circular projections by one, which, from the person who first used it (though not the inventor), is called Mercator's projection. In this there are none but right lines: all the meridians are equidistant, and continue so through the whole extent; but, on the other hand, in order to obtain the true bearing, so that the compass may be applied to the map (or chart) for the purpose of navigation, the spaces between the parallels of latitudes (which in truth are equal, or nearly so) are made to increase as they recede from the equator in a proportion which, in the high latitudes, becomes prodigiously great.

The great advantages peculiar to this projection are, that every place drawn upon it retains its true bearing with respect to all other places; the distances may be measured with the nicest exactness by proper scales, and all the lines drawn upon it are right lines: for these reasons it is the only projection in drawing maps or charts for the use of navigators. We shall show the method of this kind of projection.

Mercator's or Wright's projection of maps.—Draw the line AB, fig. 7, and divide it into as many degrees as your map is to contain in longitude, suppose 90°. At the extremities A and B raise perpendiculars, to which draw parallel lines at every single, fifth, or tenth degree of the equator, for the meridians; as in the figure, where they are drawn at every tenth degree. This done, put one foot of the compasses in the point A, and extending the other to the point in the first meridian in the equator G; or, for greater exactness, to some more distant point, as B 90; describe the quadrant FB, which divide into nine equal parts, and draw lines from A to each point of the division; or, to avoid scoring the paper, only mark where a ruler cuts the first meridian GH, at every tenth de-

gree's distance. Lastly, because the distances of the parallels from one another are marked, by this means, in the line GH, you must transfer them from that line to the side lines AC, BD, after the following manner: 1. Set one foot of the compasses in A, and extending the other to the first point above G, marked 1, transfer this distance, viz. A 1, to the lines AC, BD, and draw a line parallel to the equator AB, for the tenth parallel 2. Next transfer the distance A 2 into the lines AC, BD, from the 10th parallel to the 20th, which is to be drawn. 3. In the same manner the distances A 3, A 4, A 5, &c. laid off upon the lines AC, BD, from the immediately preceding parallels, viz. 20, 30, 40, &c. will successively point out where the parallels 30, 40, 50, &c. are to be drawn.

This is the geometrical projection, which may also be laid down by means of a scale or table of meridional parts, by the line of secants, &c.

This projection supposes the earth, instead of a globular, to have a cylindrical figure; in consequence of which, the degrees of longitude become of an equal length throughout the whole surface, and are marked out on the map by parallel lines. The circles of latitude also are represented by lines crossing the former at right angles, but at unequal distances. The further we remove from the equator, the longer the degrees of latitude become in proportion to those of longitude, and that in no less a degree than as the secant of an arch to the radius of the circle; that is, if we make one degree of longitude at the equator the radius of a circle; at one degree distant from the equator, a degree of latitude will be expressed by the secant of one degree; at ten degrees distance, by the secant of ten degrees, and so on. A map of the world, therefore, cannot be delineated upon this projection, without distorting the shape of the countries in an extraordinary manner. The projection itself is, however, as we have already observed, very useful in navigation, as it shows the different bearings with perfect accuracy, which cannot be done upon any other map.

We shall now add a more exact method of projecting particular maps, wherein the squares are so projected as to form equal diagonals throughout.

Of the projection of maps of particular parts of the world.—There are several methods of projecting particular parts of the world, we shall notice only two. First, when the meridians and parallels of latitude are right lines.

To project a map of England after this method.—England is situated between 2° E. and 6° 20′ W. from Greenwich, and between 50° and 56° N. lat.

Draw a base line AB, fig. 8, in the middle of which erect the perpendicular CD.

Assume a distance for a degree of lat. and set off as many degrees on CD as are wanted, which in this instance are 6; but as a little space beyond the limits of the country is generally left, set off 7.

Through these points draw lines parallel to AB, which will be parallels of latitude.

Respecting the degrees of longitude it must be observed, that on the equator they would be of the same length as they are on a meridian, but must gradually decrease from thence to 0 at the poles.

The following table exhibits the length in geographical miles, of a degree of longitude for every degree of latitude.

Deg. Lat.	Geograp. Miles.	Deg. Lat.	Geograp. Miles	Deg. Lat.	Geograp. Miles.
0	60,00	31	51,48	61	29,09
1	59,99	32	50,88	62	23,17
2	59,96	33	50,32	63	27,24
3	59,92	34	49,74	64	26,30
4	59,85	35	49,15	65	25,36
5	59,77	36	48,54	66	24,41
6	59,67	37	47,92	67	23,44
7	59,56	38	47,28	68	22,48
8	59,42	39	46,63	69	21,50
9	59,26	40	45,96	70	20,52
10	59,09	41	45,28	71	19.53
11	58,90	42	44,59	72	18,54
12	58,69	43	43,38	73	17,54
13	58,46	44	43,16	74	16,53
14	58,22	45	42.43	75	15,53
15	57,95	46	41,68	76	14,52
16	57,67	47	40,92	77	13,50
17	57,38	48	40,15	78	12.47
18	57,06	49	39,36	79	11,45
19	56,73	50	31,57	80	10,42
20	56,38	51	38,76	81	9,38
21	56,02	52	36,94	82	8,34
22	55,63	53	36,11	83	7,31
23	55,23	54	35,27	84	6,27
24	54,81	55	34,41	85	5,23
25	54,38	56	33,55	86	4,18
26	53,93	57	32,68	87	3,14
27	53,46	58	31,79	88	2,09
28	52,97	59	30,90	89	1,40
29	52,47	60	30,00	90	0,00
30	51,96				

To use this table, divide the assumed degree into sixty parts by a diagonal line, fig. 9: look for the number of miles answering to the degree of lat. 49, which is 39, 36, say 39½, which take off the scale, fig. 9, at *a*, and set off four times from C towards A, and the same from C towards B. The top meridian is 56° of lat. opposite which, in the table, is 33, 55, say 33½, which take from the scale, fig. 9, at *b*, and set off four times from D towards E, and the same from D towards F. Draw the meridian lines to the corresponding divisions at top and bottom, of which 0 0 is the meridian of London.

Second. When the meridians and parallels are curved lines.

To project a map of Europe by this method.—Draw a base line GH, fig. 10, in the middle of which erect the perpendicular JP, and assume any distance for 10° of latitude.

Europe extends from 36° to 72° N. lat.

Let the point J be 30°. from which set off six of the assumed distances to P, which will be the N. pole.

Number the distances 40, 50, 60, &c.

On the centre P, describe arcs passing through the points of division on the line JP, which will be parallels of latitude.

Divide the space assumed for 10° of lat. into 60 parts by a diagonal line, fig. 11.

Look into the foregoing table for the number of miles answering to 30°, which is 51,96, say 52, which take from the scale, fig. 11, at *b*.

Set this distance off on the arc 30, 30, from the centre line JP both ways.

Do the same for 40°, 50°, 60°, &c.

Through the corresponding divisions, on all the arcs, draw curve lines; which will represent the meridians.

Number the degrees of lat. and lon., which will complete the diagram.

MARANTA, *Indian arrow-root*, a genus of the monogynia order, in the monandria class of plants, and in the natural method ranking under the eighth order, scitamineæ. The corolla is ringent and quinquefid, with two segments alternately patent. There are five species, all of them herbaceous perennial exotics of the Indies, kept in some hot-houses for curiosity: they have thick, knotty, creeping roots, crowned with long, broad, arundinaceous leaves, ending in points, and upright stalks, half a yard high, terminated by bunches of monopetalous, ringent, five-parted flowers. The root of the galanga is used by the Indians to extract the virus communicated by their poisoned arrows: whence it has derived its name of arrow-root. The arundinacea, or starch plant, rises to two feet, has broad pointed leaves, small white flowers, and one seed. It is cultivated in gardens and in provision grounds in the West Indies; and the starch is obtained from it by the following process: The roots when a year old are dug up, well washed in water, and then beaten in large deep wooden mortars to a pulp. This is thrown into a large tub of clean water. The whole is then well stirred, and the fibrous part wrung out by the hands, and thrown away. The milky liquor being passed through a hair-sieve, or coarse cloth, is suffered to settle, and the clear water is drained off. At the bottom of the vessel is a white mass, which is again mixed with clean water, and drained: lastly, the mass is dried on sheets in the sun, and is pure starch.

MARATTIA, a genus of the cryptogamia filices. The capsules are oval, gaping longitudinally at top, with several cells on each side. There are three foreign species.

MARBLE, in natural history, a genus of fossils, composed chiefly of lime; being bright and beautiful stones, moderately hard, not giving fire with steel, fermenting with, and soluble in, acid, menstrua, and calcining in a slight fire. The word comes from the French marbre, and that from the Latin marmor, of the Greek μαρμαιρειν, to shine, or glitter. See LIME.

The colours by which marbles are distinguished are almost innumerable; but the most remarkable are, 1. The black marble of Flanders. 2. Plain yellow. 3. Yellow with some white veins. 4. Yellow with black dendrites. 5. Yellow with brown figures resembling ruins. 6. Black and yellow. 7. Black and white. 8. Pale yellow, with spots of a blackish-grey colour. 9. Yellow, white, and red. 10. Pale yellow. 11. Olive-colour, with deeper-coloured cross lines, and dendrites. 12. Brownish-red. 13. Flesh coloured and yellow. 14. Common red marble. 15. Crimson, white, and grey. 16. Reddish-brown lumps, on a whitish ground. 17. Bluish-grey. 18. Snowy-white.

The finest solid modern marbles are those of Italy, Blankenburg, France, and Flanders. It has also been lately discovered that very fine marble is contained in some of the western islands of Scotland. Those of Germany, Norway and Sweden, are of an inferior kind, being mixed with a kind of scaly limestone; and even several of those above-mentioned are partly mixed with this substance, though in an inferior degree. Cronstedt, however, mentions a new quarry of white marble in Sweden, which, from the specimens he had seen, promised to be excellent.

The specific gravity of marble is from 2700 to 2800; that of Carriera, a very fine Indian marble, is 2717. Black marble owes its colour to a slight mixture of iron. Mr. Bayen found some which contained five per cent. of the metal; notwithstanding which the lime prepared from it was white, but in time it acquired an ochry, or reddish-yellow colour.

MARBLE, *polishing of*, is performed by first rubbing it well with a free stone, or sand, till the strokes of the axe are worn off, then with pumice-stone, and afterwards with emery.

MARBLING, in general, the painting any thing with veins and clouds, so as to represent those of marble.

Marbling of books or paper is performed thus: Dissolve four ounces of gumarabic into two quarts of fair water; then provide several colours mixed with water in pots or shells, and with pencils peculiar to each colour, sprinkle them by way of intermixture upon the gum water, which must be put into a trough, or some broad vessel; then with a stick curl them, or draw them out in streaks, to as much variety as may be done. Having done this, hold your book or books close together, and only dip the edges in, on the top of the water and colours, very lightly; which done, take them off, and the plain impression of the colours in mixture will be upon the leaves; doing as well the ends as the front of the book in the like manner.

Marbling books on the covers is performed by forming clouds with aquafortis, or spirit of vitriol mixed with ink, and afterwards glazing the covers.

MARCGRAVIA, a genus of the polyandria monogynia class of plants, the corolla whereof consists of a single petal, of a conico-oval figure; and its fruit is a globose berry, with a single cell, containing a great number of very small seeds. There is one species, a shrub of the West Indies.

MARCHANTIA, a genus of the cryptogamia class of plants, the corolla of which is monopetalous, turbinated, and shorter than the cup; in the lower cavity of which there are contained several naked seeds, of a roundish but compressed figure. There are seven species, five of them British.

MARCIONITES, christians in the second century, thus denominated from their leader Marcion, who maintained that there were two principles or gods, a good and a bad one.

MARCOSIANS, a sect of christians in the second century, so called from their leader Marcus, who represented the supreme God as consisting not of a trinity, but a quaternity, viz. the ineffable, silence, the father, and truth.

MARE. See EQUUS.

MARGARITERIA, a genus of the diœcia octandria

class and order. The male calyx is four-toothed; corolla four-petalled. Female calyx and corolla as above; styles four or five. There is one species, a native of Surinam.

MARICA, a genus of the trigynia monogynia class and order. The calyx is six-parted; stigma petal-form, trifid; capsule three-celled, inferior. There is one species, a fleshy bulb of Guiana.

MARILLA, a genus of the class and order polyandria monogynia. The calyx is five-leaved; corolla five-petalled; capsule four-celled, many seeded; stigma simple. There is one species, a native of the West Indies.

MARK, *knights of St.*, an order of knighthood in the republic of Venice, under the protection of St. Mark the evangelist. The arms of the order are, gules, a lion winged or, with this device, "Pax tibi Marce evangelista." This order is never conferred but on those who have done signal service to the commonwealth.

Mark or Marc, also denotes a weight used in several states of Europe, and for several commodities, especially gold and silver. In France, the mark is divided into 8 oz. or 64 drachms, or 192 derniers or pennyweights, or 160 esterlines, or 300 mailles, or 640 felins, or 4608 grains. In Holland the mark-weight is also called troy-weight, and is equal to that of France. When gold and silver are sold by the mark, it is divided into 24 caracts.

Mark is also used in England for a money of account, and in some other countries for a coin. The English mark is two-thirds of a pound sterling, or 13*s.* 4*d.* and the Scotch mark is of equal value in Scotch money of account. The mark-lubs, or lubeck-mark, used at Hamburgh, is also a money of account, equal to one-third of the rix-dollar, or to the French livre: each mark is divided into 16 sols-lubs. Mark-lubs is also a Danish coin equal to 16 sols-lubs. Mark is also a copper and silver coin in Sweden.

MARKET. A market is less than a fair, and is commonly held once or twice a week. According to Bracton, one market ought to be distant from all others at least six miles and a half and a third of a half: but no market is to be kept within seven miles of the city of London: but all butchers, victuallers, &c. may hire stalls and standings in the flesh-markets there, and sell meat and other provisions, four days in a week. Every person who has a market is entiled to receive toll for the things sold in it; and, by ancient custom, for things standing in the market, though nothing be sold: but by keeping a market in any other manner than it is granted, or extorting of tolls or fees where none are due, they may be forfeited.

In London every shop in which goods are exposed publicly to sale, is market overt for such things only as the owner professes to trade in: though if the sale is in a warehouse and not publicly in the shop, the property is not altered. But if goods are stolen from one, and sold out of the market overt, the property is not altered, and the owner may take them wherever he finds them. 5 Rep. 83.

If a man buy his own goods in a market, the contract shall not bind him, unless the property had been previously altered by a former sale.

MARLE. A mixture of carbonat of lime and clay, in which the carbonat considerably exceeds the other ingredient, is called marle. Its structure is earthy. Opaque, sometimes in powder. Specific gravity from 1.6 to 2.877. Colour usually grey, often tinged with other colours. Effervesces with acids. Some marles crumble into powder when exposed to the air; others retain their hardness for many years. Marles may be divided into two varieties: 1. Those which contain more silica than alumina. 2. Those which contain more alumina than silica. Mr. Kirwan has called the first of these siliceous, the second argillaceous marles. Attention should be paid to this distinction when marles are used as a manure.

Marle, *bituminous*, is found in different parts of Germany. Colour greyish or brownish black. Found massive. Shistoes. Plates flat or waved. Opaque. Feels soft. Easily broken. Moderately heavy. Effervesces with acids. Burns before the blowpipe, leaving black scoriæ.

MARLINS, in artillery, are tarred white skains, or long wreaths or lines of untwisted hemp, dipped into pitch or tar, with which cables and other ropes are wrapped round, to prevent their fretting and rubbing in the blocks or pulleys through which they pass. The same serves in artillery upon ropes used for rigging gins, usually put up in small parcels called skains.

MARMOTTE. See Mus.

MARQUE. See Letters *of Marque*.

MARQUETRY, or Inlaid work, is a curious work composed of several fine hard pieces of wood, of various colours, fastened in thin slices on a ground, and sometimes enriched with other matters, as silver, brass, tortoise-shell, and ivory; with these assistances the art is now capable of imitating any thing, whence it is by some called the art of painting in wood.

The ground on which the pieces are to be arranged and glued is usually of well-dried oak or deal; and is composed of several pieces glued together, to prevent its warping. The wood to be used in marquetry is reduced into leaves of the thickness of a line, or the 12th part of an inch, and is either of its natural colour, or stained, or made black to form the shades by other methods: this some perform by putting it in sand heated very hot over the fire; others by steeping it in lime-water and sublimate; and others in oil of sulphur. The wood being of the proper colours, the contours of the pieces are formed according to the parts of the design they are to represent: this is the most difficult part of marquetry, and that which requires the most patience and attention.

The two chief instruments used in this work are a saw and a wooden vice, which has one of its chaps fixed, and the other moveable; which is open and shut by the foot, by means of a cord fastened to a treadle.

MARQUIS, a title of honour, next in dignity to that of duke, first given to those who commanded the marches, that is, the borders and frontiers of countries.

Marquises were not known in England till the reign of king Richard II. and the year 1337.

MARRIAGE, a contract, both civil and religious, between a man and a woman.

Taking marriage in the light of a civil contract, the law treats it as it does all other contracts: allowing it to be good and valid in all cases where the parties, at the time of making it, were, in the first place, willing to contract; secondly, able to contract; and, lastly, actually

did contract in the proper forms and solemnities required by law. 1 Black. 433.

MARROW. See ANATOMY.

MARRUBIUM, *white horehound*, a genus of the gymnospermia order, in the didynamia class of plants, and in the natural method ranking under the 42d order, verticillatæ. The calyx is salver-shaped, rigid, and ten-striated; the upper lip of the corolla bifid, linear and straight. There are 11 species, the most remarkable of which is the vulgar, a native of Britain, growing naturally in waste places, and by way-sides near towns and villages, but not common. It has a strong and somewhat musky smell, and bitter taste. It is reputed attenuant and resolvent; an infusion of the leaves in water, sweetened with honey, is recommended in asthmatic and phthisical complaints, and most other diseases of the breast and lungs.

MARS, in astronomy, one of the superior planets, moving round the sun in an orbit between those of the earth and Jupiter. See ASTRONOMY.

MARSHAL, in its primary signification, means an officer who has the command or care of horses; but it is now applied to officers who have very different employments, as earl-marshal, knight-marshal, or marshal of the king's house, &c.

MARSHAL *of the king's bench*, an officer who has the custody of the king's bench prison in Southwark. This officer is obliged to give his attendance, and to take into his custody all persons committed by that court.

MARSHAL *of the exchequer*, an officer to whom that court commits the king's debtors.

MARSHALLEA, a genus of the class and order syngenesia polygamia æqualis, little known.

MARSHALLING a coat, in heraldry, is the disposal of several coats of arms belonging to distinct families, in one and the same escutcheon or shield, together with their ornaments, parts, and appurtenances.

MARSHALSEA-COURT, is a court of record, originally instituted to hear and determine causes between the servants of the king's household and others within the verge of the court, and has jurisdiction of things within the verge of the court, and of pleas of trespass, where either party is of the king's family; and of all other actions personal, wherein both parties are the king's servants; but the court has also power to try all personal actions, as debt, trespass, slander, trover, action on the case, &c. between party and party, the liberty whereof extends 12 miles about Whitehall.

The judges of this court are the steward of the king's household, and high marshal for the time being; the steward of the court, or his deputy, is generally an eminent counsel.

If a cause of importance is brought in this court, it is generally removed into the court of king's bench or common pleas by a habeas corpus cum causa.

MARSILEA, a genus of the cryptogamia class of plants, without any corolla or cup: the antheræ are four, and placed on an obtusely conic body; the fruit is of a roundish figure, consisting of four cells, in each of which are contained several roundish seeds. There are three species.

Under this genus are comprehended the salvinia of Micheli, and pilularia of Dillenius.

MARTIAL LAW, is the law of war, which entirely depends on the arbitrary power of the prince, or of those to whom he has delegated it. For though the king can make no laws in time of peace without the consent of parliament, yet in time of war he uses an absolute power over the army.

MARTIN. See HIRUNDO, and MUSTELA.

MARTLETS, in heraldry, little birds represented without feet, and used as a difference or mark of distinction for younger brothers.

MARTNETS, in a ship, small lines fastened to the leech of a sail, reeved through a block on the topmast-head, and coming down by the mast to the deck. Their use is to bring the leech of the sail close to the yard to be furled.

MARTYNIA, a genus of the angiospermia order, in the didynamia class of plants, and in the natural method ranking under the 40th order, personatæ. The calyx is quinquefid; the corolla ringent, the capsule ligneous, covered with a bark, with a hooked beak, trilocular, and bivalved. There are 60 species, tender, herbaceous, flowery, plants of South America.

MARYGOLD. See CALENDULE; and for MARSH-MARYGOLD, see CALTHA.

MASON, a person employed under the direction of an architect, in the raising of a stone building. See ARCHITECTURE.

MASSETER. See ANATOMY.

MASSICOT, a name given to the yellow oxide of lead, as minium is applied to the red oxide.

MASSONIA, a genus of the class and order hexandria monogynia. The corolla is inferior, with 6-parted border; filaments on the neck of the tube; capsule 3-winged, 3-celled, many-seeded. There are four species, bulbs of the Cape.

MAST, in naval architecture, a large timber in a ship, for sustaining the yards, sails, &c.

In large vessels there are four masts, viz. the mainmast, foremast, mizenmast, and bowsprit. The mainmast is the principal one, standing in the middle of the ship: its length, according to some, should be $2\frac{1}{2}$ that of the midship-beam. Others give the following rule for finding its length, viz. multiply the breadth of the ship, in feet, by 24; from the product cut off the last figure towards the right hand, and the rest will be the length required. Thus suppose the length of the midship-beam was 30 feet; then $30 \times 24 = 720$, from which cutting off the last figure, there remains 72 feet for the length of the mainmast. And as for the thickness of the mainmast, it is usual to allow an inch to every yard in length. See SHIP-BUILDING.

MASTER AND SERVANT. In London and other places the mode of hiring is by what is commonly called a month's warning or a month's wages: that is, the parties agree to separate on either of them giving to the other a month's notice for that purpose; or, in lieu thereof, the party requiring the separation to pay, or give up, a month's wages. But if the hiring of a servant is general, without any particular time specified, it will be construed to be a hiring for a year certain; and in this case if the servant departs before the year, he forfeits all his wages. Noy, Max. 107. And where a servant is hired for one year certain, and so from year to year as long as

both parties shall agree, and the servant enters upon a second year, he must serve out that year, and is not merely a servant at will after the first year. If a woman servant marries she must nevertheless serve out her term; and her husband cannot take her out of her master's service.

If a servant is disabled in his master's service by an injury received through another's default, the master may recover damages for loss of his service. And also a master may not only maintain an action against any one who entices away his servant, but also against the servant; and if without any enticement a servant leaves his master without just cause, an action will lie against another who retains him with a knowledge of such departure.

A master has a just right to expect and exact fidelity and obedience in all his lawful commands; and to enforce this he may correct his servant in a reasonable manner, but this correction must be to enforce the just and lawful commands of the master. Bul. N. P. 18.

In defence of his master a servant may justify assaulting another; and though death should ensue it is not murder, in case of any unlawful attack upon his master's person or property.

Acts of the servant are, in many instances, deemed acts of the master; for as it is by indulgence of law that he can delegate the power of acting for him to another, it is just he should answer for such substitute, and that his acts being pursuant to the authority given him, should be deemed the acts of his master. 4 Bac. Abr. 583. If a servant commits an act of tresspass by command or encouragement of his master, the master will be answerable; but in so doing his servant is not excused, as he is bound to obey the master in such things only as are honest and lawful.

If a servant of an inkeeper robs his master's guest, the master is bound to make good the loss. Also, if a waiter at an inn sells a man bad wine, by which his health is impaired, an action will go against the master: for his permitting him to sell it to any person is deemed an implied general command. 1 Black. 430. In like manner if a servant is frequently permitted to do a thing by the tacit consent of his master, the master will be liable, as such permission is equivalent to a general command.

If a servant is usually sent upon trust with any tradesman, and he takes goods in the name of his master upon his own account, the master must pay for them: and so likewise if he is sent sometimes on trust, and other times with money; for it is not possible for the tradesman to know when he comes by the order of his master, and when by his own authority, or when with and without money. 1 Str. 506. But if a man usually deals with his tradesmen himself, or constantly pays them ready money, he is not answerable for what his servant may take up in his name; for in this case there is not, as in the other, any implied order to trust him. Or if the master never had any personal dealings with the tradesman, but the contracts have always been between the servant and the tradesman, and the master has regularly given his servant money for payment of every thing had on his account, the master shall not be charged. Esp. N. P. 115. Or if a person forbids his tradesmen to trust his servant on his account, and he continues to purchase upon credit, he is not liable. The act of a servant, though he has quitted his master's service, has been held to be binding upon the master, by reason of the former credit given him on his master's account, and it not being known to the party trusting that he was discharged. 4 Bac. Abr. 586.

The master is also answerable for any injury arising by the fault or neglect of his servant when executing his master's business, 6 T. R. 659: but if there is no neglect or default in the servant the master is not liable. Esp. Rep. 533.

If a smith's servant lames a horse whilst shoeing him, or the servant of a surgeon makes a wound worse, in both these cases an action for damages will lie againt the master, and not against the servant. But the damage must be done while the servant is actually employed in his master's service, otherwise he is liable to answer for his own misbehaviour or neglect.

A master is likewise chargeable if his servant casts any dirt, &c. out of the house into the common street; and so for any other nuisance occasioned by his servants, to the damage or annoyance of any individual, or the common nuisance of his majesty's people. Lord Raym. 264.

A servant is not answerable to his master for any loss which may happen without his wilful neglect; but if he is guilty of fraud or gross negligence, an action will lie against him by his master.

A master is not liable in trespass for the wilful act of his servant; as by driving his master's carriage against another; done without the direction or assent of his master, no person being in the carriage when the act was done. But he is liable to answer for any damage arising to another from the negligence or unskilfulness of his servant acting in his employ. M'Manus v. Crickett, Mich. 41 G. III.

Master of arts, is the first degree taken up in foreign universities, and for the most part in those of Scotland, but the second in Oxford and Cambridge; candidates not being admitted to it till they have studied seven years in the university.

Master in chancery. The master in chancery are assistants to the lord chancellor and master of the rolls; of these there are some ordinary, and others extraordinary: the masters in ordinary are 12 in number, some of whom sit in court every day during the term, and have referred to them interlocutory orders for stating accounts, and computing damages and the like; and they also administer oaths, take affidavits, and acknowledgments of deeds and recognizances. The masters extraordinary are appointed to act in the country, in the several counties of England, beyond 10 miles distant from London; by taking affidavits, recognizances, acknowledgments of deeds, &c. for the ease of the suitors of the court.

Master of the faculties, an officer under the archbishop of Canterbury, who grants licences and dispensations.

Master of the horse, a great officer of the crown, who orders all matters relating to the king's stables, races, breed of horses, and commands the equerries and all the other officers and tradesmen employed in the king's stables. His coaches, horses, and attendants, are the king's, and bear the king's arms and livery.

general consideration of what is usually denominated animal and vegetable diet.

Master of the rolls, is an assistant to the lord chancellor of England in the high court of chancery; and in his absence hears causes there, and gives orders. His salary is 1200*l.* per annum.

Master of a ship, the same with captain in a merchantman; but in a king's ship he is an officer who inspects the provisions and stores, and acquaints the captain with what is not good, takes particular care of the rigging and of the ballast, and gives directions for stowing the hold; he navigates the ship under the directions of his superior officers; sees that the log and log-book are duly kept; observes the appearance of coasts; and notes down in his journal any new shoals or rocks under water, with their bearing and depth of water, &c.

Master at arms, in a king's ship, an officer who daily, by turns, as the captain appoints, is to exercise the petty officers and ship's company; to place and relieve sentinels; to see the candles and fire put out according to the captains orders; to take care the small arms are kept in good order, and to observe the directions of the lieutenant at arms.

MASK, in field fortification: it sometimes happens that a ditch or fosse must be dug in an exposed situation; in this case it will be absolutely necessary for the artificers and workmen to get under cover by means of masking themselves in such a manner as to answer the double purpose of executing their immediate object, and of deceiving the enemy with respect to the real spot they occupy.

To effect the latter purpose several masks must be hastily thrown up, whilst the men are employed behind one; by which means the enemy will either mistake the real point, or be induced to pour his fire in several directions, and thus weaken its effect.

A mask is generally six feet high. Bags made of wad or wool are too expensive on these occasions; nor are gabions, stuffed with fascines, seven or eight feet high, to be preferred; for if the fascines are tied together they will leave spaces between them in the gabions; and if they are not bound together, they will be so open at top as to admit shot, &c.

In order to obviate these inconveniences the following method has been proposed: Place two chandeliers, each seven feet high and two broad, between the uprights, after which fill up the vacant spaces with facines nine feet high, upon six inches diameter. One toise and a half of epaulement will requre two chandeliers and 60 fascines to mask it.

The engineer, or artillery officer, places himself behind this mask, and draws his plan.

As you must necessarily have earth, &c. to complete your work, these articles may be brought in shovels, sacks, or baskets; and if the quarter whence you draw them should be exposed to the enemy's fire, cover that line, as well as the line of communication, between the trenches, or the parallels, with a mask.

If you cannot procure earth and fascines, make use of sacks stuffed with wool, &c. and let their diameters be three feet, and their length likewise three; and let the outside be frequently wetted to prevent them from catching fire.

MASTOIDES. See Anatomy.

MATCH, a kind of rope slightly twisted, and prepared to retain fire for the uses of artillery, mines, fireworks, &c. It is made of hempen tow, spun on the wheel like cord, but very slack; and is composed of three twists, which are afterwards again covered with tow, so that the twists do not appear: lastly, it is boiled in the lees of old wines. This, when once lighted at the end, burns on gradually and regularly, without ever going out, till the whole is consumed: the hardest and driest match is generally the best.

Match, *quick*, used in artillery, is made of three cotton strands drawn into lengths, and put into a kettle just covered with white-wine vinegar, and then a quantity of saltpetre and mealed powder is put into it, and boiled till well mixed. Others put only saltpetre into water, and after that take it out hot, and lay it into a trough with some mealed powder, moistened with some spirits of wine, thoroughly wrought into the cotton by rolling it backwards and forwards with the hands; and when this is done they are taken out separately, drawn through mealed powder, and dried upon a line.

MATERIA MEDICA. "The materia medica (says Dr. Darwin) includes all those substances which may contribute to the restoration of health." If, however, medicine be defined the art of *preventing*, as well as of curing, diseases, the science of which we are now to treat ought, by consequence, to comprehend the preservatives of living existence, as well as the restoratives of healthy action. Instead, therefore, of restricting this article to the mere enumeration and discussion of drugs, we shall, in the first place, introduce some general remarks on those substances which are employed as articles of diet or food.

PART I.

DIETETICS.

Organic life appears to be influenced and supported by two leading principles: 1st, fibrous excitation; and, 2dly, the substitution of nutritious particles, in place of those which are constantly dissipated or abraded. The power by which this last object is effected has been denominated by the author of Zoonomia, animal appetency. The principal and prime organs by which it is exerted, or the media through which new matter is originally communicated, are those which are termed the digestive and assimilating; it has, however, recently been conjectured that the organs of digestion are not the sole organs of nutrition, but that both the external surface of the body, and likewise the lungs, are media for the admission into the system of proper nutrative matter. Accordingly we find the class nutrientia, in the materia medica of the author just quoted, to comprehend not merely those substances which are received into the stomach as food, but also the matter which is taken into the lungs in the act of respiration, as likewise air, water, and other substances that may be applied naturally or artificially to the outer skin. To inquire into the grounds upon which this doctrine is established, that the lungs, the stomach, and the surface of the body, each affords instruments in common of actual nutrition, does not fall within the province of the present article. See Physiology. It will be proper here to confine ourselves to the

general consideration of what is usually denominated animal and vegetable diet.

OF ANIMAL FOOD.

That man is designed by nature for a mixture of animal and vegetable food, is obvious from the structure of his organs, both of mastication and digestion. That the flesh of animals contains more nutritive matter, and that it stimulates the absorbent and secerning vessels more powerfully, than vegetable aliment, is demonstrated by the superior warmth and strength which in a state of health we experience after a meal of flesh than of vegetables: of the former (animal flesh), that, in general, which is of the darkest colour, contains more nutritive matter, and stimulates our vessels with more energy, than the white kinds: indeed the flesh of those animals which are carnivorous, or which live entirely on animal food, seldom enters into the diet of European, or civilized nations. The greater stimulating virtue of this kind of food has been attributed to the greater quantity which it has been supposed to contain of volatile alkali. Dr. Darwin, however, properly questions whether it is not rather the elements only of this principle that are contained even in the strongest dark-coloured animal flesh.

Next in strength to the flesh of carnivorous animals ought to rank that of those animals when killed after full growth, the young of which afforded a softer, whiter, more digestible, but less nutritious, food, such as the sheep, the bullock, the hog, and likewise several of the shell-fish, as lobsters, crabs, muscles, &c. in which class may likewise be enumerated several fish that are destitute of scales or shells, as ell, barbolt, tench, smelt, turtle, turbot. Of the fowl kind the bustard, wood-pecker, starling, sparrow, goose, duck, and lapwig, ought to be arranged in this second class. These, with a due mixture of vegetable aliment, constitute the best kinds of food for healthy and athletic individuals, whose digestion is powerful, and who have a firm fibre.

The flesh of the young animals, as of lamb, veal, and ucking pigs, afford a less stimulating and nutritious, but more digestible food: these meats are consequently most congenial to persons of less muscular energy, who have more feeble powers of digestion, and who accustom themselves to but little exercise: they are adapted to the hypochondriac and should be principally used as aliment by individuals who are disposed to those kind of affections which have received the vulgar and indiscriminate appellation of scorbutic.

A still milder, but, in the same proportion, less nutritive food, is furnished by the white meats, such as the domestic fowl, partridge, pheasant, and their eggs, with oysters and young lobsters. These, from their bland and unacrimonious nature, are generally allowed to convalescents from acute diseases: they are peculiarly suitable to very weak stomachs, and ought in general to form the first articles in the diet of females after childbirth. The major part of the river fish which have scales, as pike, perch, and gudgeon, are possessed of very inferior nutritive faculty.

OF MILK AND ITS PRODUCTS.

Milk partakes of the properties of both animal and vegetable aliment: it may be separated by rest or by agitation into cream, buttermilk, whey, and curd. The cream is easier of digestion by the adult stomach, on account of its containing less of the caseous, or cheesy part; it is likewise on this account more nutritive. Butter contains still more nutriment, and is likewise, if not taken to excess, exceedingly easy of digestion, and is by no means calculated to generate unpleasant humours in the body. If given without any separation of its principles by artificial preparation, it might be admitted into the diet of infancy with much greater propriety than other articles which are employed with less apprehension of injury. Buttermilk is agreeable, bland, and gently nutritive. Whey is the least nutritious, and most easy of digestion. It is on this account ordered with the utmost propriety to those invalids whose constitutions have been rendered too irritable to bear the stimulus of more solid and nutritive aliment. Cheese is of various kinds, arising principally from the greater or less quantity of cream that it contains. Those cheeses which are broken to pieces in the mouth with most readiness are, for the most part, most easy of digestion, and most nutritive. Many kinds of cheeses are a considerable time in undergoing chemical change in the stomach; and on this account, although difficult of digestion, do not disagree with weak stomachs. Dr. Darwin observes that he has seen toasted cheese vomited up a whole day after it was eaten, without having become perceptibly altered, or given any uneasiness to the patient.

New cow's-milk is the food of infants, and is by far the best substitute for the milk of the mother, if this last be not afforded in sufficient quantity or quality by the parent, which, however, is seldom the case. The stomachs of children abound with acidity; and milk, which is always curdled before it is assimilated, is consequently digested with more facility in the earlier than in the more advanced periods of life. It is on this account likewise that certain vegetable substances, which have a great tendency to acidity, are exceedingly injurious to the infantile stomach. See the article Infancy.

OF VEGETABLE FOOD.

The seeds, roots, leaves, and fruits, of plants, particularly the two former, constitute a very material part of the food of mankind. According to the opinion of Dr. Cullen, and other physiologists, the quantity of actual nourishment that these contain, is in proportion to the quantity of sugar that they can be made to produce; it is imagined that the mucilage which the farinaceous seeds contain, is changed in the granary to starch; and that this starch, in the processes to which the seeds are afterwards subjected, or by digestion in the stomach, is at length converted into saccharine principle. See Physiology. The farinaceous seeds are wheat, barley, oats, rye, millet, maize or Indian corn, &c. The roots of this class are the sugar-root, the common carrot, beet, and polypody. Those with less of the saccharine principle, and which afford a tender farina, are the turnip-rooted cabbage, the parsnip, parsley root, asparagus, turnips, potatoes, &c.; all of which, if less nutritive, are better suited to weakly organs of digestion than those in which the sugar is more abundant.

Other vegetables contain oil, sugar, mucilage, or acid, in various proportions, diluted with much water: these

are but slightly nutrimental; and are, for the most part, injurious to delicate stomachs especially, unless taken with moderation; these are the apple, pear, plum, apricot, nectarine, peach, strawberry, grape, orange, melon, cucumber, dried figs, raisins, and a great variety of other roots, seeds, leaves, and fruits. Of these it may be observed generally, that those which are cold, watery, and sweet, are most calculated to prove indigestible, and consequently injurious.

DIFFERENT METHODS OF DRESSING VICTUALS.

Various modes of preparing and dressing both animal and vegetable articles of food have been contrived, in order to render them more palatable, and better adapted to the stomach. By boiling, animal flesh is, in some measure, deprived of its nourishing juice, which is with more or less facility given out to, and incorporated with, the broth: this last then contains the most nutritious part of the meat; but unless stronger than is ordinarily used, it is too diluted to admit of an easy digestion. Broths likewise have a remarkable tendency to acidity, particularly when made from the flesh of young animals, as of lamb and veal; and on this account also are much less congenial to weak stomachs than is generally imagined. The various jellies, which contain the gelatinous and nutritive, to the exclusion of the fibrous part of animal flesh, are in general much more suitable to the invalid and the convalescent than either broths or soups. Perhaps the most eligible mode of preparing animal food is by the process called stewing; for by this process its nitritious and substantive parts are concentrated and preserved. It is scarcely necessary to observe that the gravy of boiled meat contains its notritive parts in a state of concentration; it is digested with facility; and gravy is therefore the best mode of giving animal food to very young infants.

Roasting preserves the nutritive part of flesh from dissipation in a greater degree than boiling: and it has been asserted by an observant author (Dr. Willich) that "one pound of roast meat is, in real nourishment, equal to two or three pounds of boiled meat." It ought however to be noticed, that the fat of meat treated in this way has undergone some degree of chemical decomposition from its exposure to heat, and is in consequence more oppressive to delicate stomachs, and generally less salutary, than that of boiled flesh. Both baking and frying are upon similar principles improper methods of preparing animal food. Smoked meats, as prepared hams, are hard of digestion. They should only be taken in small quantities, and rather as condiment than food.

The art of cookery, as applied to vegetable substances, is principally useful in destroying the native acrimony, and rendering the texture softer of some, and by converting the acerb juices of others into saccharine matter. The boiling of cabbage, of asparagus, &c. are examples of the one, the baking of unripe pears is an instance of the other. The above are all chemical processes; they are too familiar to need description.

Another mode by which the nourishment of mankind is facilitated, is the mechanic art of grinding farinaceous seeds into powder; and, in some instances, exposing them afterwards to a fermenting process, as in the making of bread, and then to the action of fire by baking or boiling. The mill-stones, by which the process of grinding is effected, have been quaintly termed the artificial teeth of society. It has been suggested by Dr. Darwin, that "some soft kinds of wood, especially when they have undergone a kind of fermentation, and become looser, might, by being subjected to the action of the mill-stones, be probably used as food in the times of famine. Nor is it improbable," continues our ingenious speculator, "that hay which has been kept in stacks, so as to undergo the saccharine process, may be so managed by grinding and by fermentation with yeast, like bread, as to serve in part for the sustenance of mankind in times of great scarcity. Dr. Priestley gave to a cow, for some time, a strong infusion of hay in large quantities for drink, and found that she produced during this treatment above double the quantity of milk. Hence if bread cannot be made from ground hay, there is great reason to suspect that a nutritive beverage may be thus prepared, either in its saccharine state, or fermented into a kind of beer. In times of great scarcity there are other vegetables, which, though not in common use, would most probably afford wholesome nourishment, either by boiling them, or drying and grinding them, or by both those processes in succession. Of these perhaps are the tops and barks of all those vegetables which are armed with thorns or prickles, as gooseberry-trees, holly, gorse, and perhaps hawthorn. The inner bark of the elm-tree makes a kind of gruel; and the roots of fern, and probably very many other roots, as of grass and clover taken up in winter, might yield nourishment, either by boiling or baking, and separating the fibres from the pulp by beating them; or by getting only the starch from those which possess an acrid mucilage, as the white betony. And the alburnum of perhaps all trees, and especially of those which bleed in spring, might produce a saccharine and mucilaginous liquor, by boiling it in the winter or spring."

OF DRINK.

"Water," says Dr. Darwin, "must be considered as a part of our nutriment, because so much of it enters the composition of our fluids; and because vegetables are believed to draw almost the whole of their nourishment from this source." It may, however, be questioned whether pure elementary water taken into the stomach acts upon the system as a nutrimental matter in any other mode than by procuring the solution, and thus facilitating assimilation, of solid aliment.

Water is the natural and proper drink of man. It is the basis of all other liquids; and the larger proportion of water that enters their composition, the more easily, in a state of health, and provided proper food has been taken, are the solution and digestion of such food effected.

This fluid, however, is never or seldom taken in a state of entire purity. Even in nature's laboratory it is invariably impregnated with foreign substances; and it is this admixture of extraneous matter which constitutes its varieties. Thus we have snow water, rain water, spring water, river water, and water from lakes, wells, and swamps, each possessing their individual characteristics.

Spring water is, in general, most free from impurities; it is, however, less suited for drink than the water of rivers, as it almost constantly contains calcareous, or sa-

line ingredients. The calcareous earth dissolved in the water of many springs, has been supposed indeed by Dr. Darwin to contribute to our nourishment in the manner that lime proves useful in agriculture. This principle, however, is not perhaps fully established; and we believe that too much stress has by theorists in general been laid on the specific qualities of water, as modifying both the bodily and intellectual character of individuals and nations. The cretinism and fatuity of the Alpine valleys were formerly attributed to the waters of these countries, but are now more commonly, and we believe more justly, referred to constitutional propensity, innutritious food, and a humid unhealthy atmosphere.

That water however possesses great varieties, according to the nature of the soil and situation of the place in which it is produced or contained, is undeniable; and we shall here extract part of what is observed on these varieties by an attentive and judicious observer.

"*Spring water*," says Dr. Willich, "originates partly from that of the sea, which has been changed into vapours by subterraneous heat, and partly from the atmosphere. As it is dissolved and purified in a variety of ways before it becomes visible to us, it is lighter and purer than other waters.

"*Well water*. Wells opened in a sandy soil are the purest. The more frequently a well is used, the better; for the longer water stands unmoved, the sooner it turns putrid.

"*River water* is more pure and wholesome if it flows over a sandy and stony soil, than if it passes over muddy beds, or through towns, villages, and forests: water is rendered foul by fish, amphibious animals, and plants.

"*Lake water* much resembles river water, but being less agitated it is more impure. The water which, in cases of necessity, is obtained from swamps and ditches, is the worst of all; because a great variety of impurities are there collected, which, in a stagnant and soft soil, readily putrify.

"*Rain water* is also impure, as it contains many saline and oily particles, soon putrefies, and principally consists of the joint exhalations of animals, vegetables, and minerals, of an immense number and variety of small insects and their eggs, seeds of plants, and the like. Rain water is particularly impure in places filled with many noxious vapours; such as marshy countries, and large manufacturing towns, where the fumes of metallic and other substances are mixed with rain. In high and elevated situations, at a distance from impure exhalations, if no strong winds blow, and after a gentle shower, rain water is then purest. In summer, however, on account of the copious exhalations, rain water is most objectionable.

"*Snow water* possesses the same properties as rain water, but is purer; both are soft, that is, without so many mineral and earthy particles as spring, well, and river waters. *Hail water*, being produced in the higher regions of the atmosphere, is still purer from its congelations. Lastly, *dew*, as it arises from the evaporation of various bodies of the vegetable and animal kingdoms, is more or less impure, according to the different regions and seasons."

Of the different kinds and qualities of fermented and spirituous liquors, it does not fall within the compass of the present article to treat. They all consist of water as their base or vehicle, of more or less alcohol or ardent spirit according to their different degrees of strength, of sugar, and of the particular ingredient by which their nature is determined; such as the grape in wine, the apple and pear in cyder and perry, the malt and hop in beer, &c. &c. (See the respective articles in their alphabetical order.) It is only necessary here to observe, that, with few exceptions, fermented liquors, when immoderately taken, are more detrimental than elementary fluids in proportion to the quantity that they contain of alcohol, or ardent spirit.

With respect to the China tea and the coffee-berry, which have lately come into such general use, we believe them to be much less injurious to the animal economy than some theorists have been disposed to conjecture. In excess, however, and when indulged in as substitutes for, and, as is sometimes the case, almost to the exclusion of, nourishing diet, they are highly deleterious, as they tend to the induction of a morbidly irritable condition of the nervous system. It deserves to be remarked, that these stimuli do not, like alcohol, produce those formidable, and often irremediable, disorders, affections of the liver, dropsy, and apoplexy.

An enumeration of spices (which, like spirituous liquors, are used as articles of diet with too great freedom) will be found under the head Aromatics, in a subsequent section of this article.

PART II.

MEDICINALS.

We now proceed to the second division of our subject, or to the consideration of the materia medica in its more ordinary and limited signification.

Various divisions and modes of classification of those articles which are used in medicine, have been proposed and adopted by different authors. Some systematic writers arrange the articles of the materia medica according to their alphabetical order: others have taken for the basis of their arrangement the more sensible properties of drugs, as detected by the taste; thus reducing medicines to the different heads of bitterness, sweetness, astringency, acidity, &c.: while some have been regulated in their classification of medicinal articles, by their characters as objects in natural history. "As, however, the study of the materia medica is merely the study of the medicinal properties of certain substances, it is evident that the method of arranging them as they agree in producing effects on the living system is the one best calculated to fulfil all its objects." Murray.

Among the different plans of arrangment which have been framed on this principle, that adopted by Mr. Murray, in his late work on the materia medica, appears liable to the fewest objections. It is founded on the principle of Dr. Brown, "that medicines operate by stimulating the living fibre, or exciting it into motion." See the article Brunonian System. This proposition, however, was received and applied by its author in too unlimited a sense. In the first place, stimulation differs not merely in *degree*, but also in *kind*; or, in other words, one given medicine cannot by any regulation of its quantity be made to produce the same effects which result from the agency of another; some are more diffusible and transient, others more slow and permanent in

their action; some affect the universal system in almost an equal degree, while the operation of others is more especially, and in some instances almost exclusively, directed to a certain part. They have all likewise properties peculiar to themselves.

But beside this general and very important modification of the Brunonian materia medica, it is necessary further to take into view, that medicines sometimes appear to display their agency even on the living body almost entirely upon chemical or mechanical principles; these last modes of operation, although less common and extensive than were supposed in the ancient systems of medicine, must still be admitted as interfering with the universality, and opposing the unqualified assumption, of Dr. Brown, to which we have just alluded.

Guided by these views, Mr. Murray has adopted the general division of medicines under the four heads of *universal stimulants, local stimulants, chemical remedies,* and *mechanical remedies,* which are subdivided in the following manner:

TABLE of CLASSIFICATION.

A. General stimulants.		
	a. Diffusible.	Narcotics.
		Antispasmodics.
	b. Permanent.	Tonics.
		Astringents.
B. Local stimulants.		Emetics.
		Cathartics.
		Emmenagogues.
		Diuretics.
		Diaphoretics.
		Expectorants.
		Sialagogues.
		Errhines.
		Epispastics.
C. Chemical remedies.		Refrigerants.
		Antacids.
		Lithontriptics.
		Escharotics.
D. Mechanical remedies.		Anthelmintics.
		Demulcents.
		Diluents.
		Emollients.

The objections which still lie against this which we have chosen as the most perspicuous and comprehensive arrangement of medicines will be urged, as we proceed to make some observations on their subdivisions, in the order of the above table.

The following, then, may be regarded, with some few exceptions, as an abridgment, or condensation, of the materia medica department of Mr. Murray's treatise. The names of the articles are adopted from the last edition, recently published, of the Parmacopœia collegii regii Medicorum Edinburgensis. In this edition the simples are principally indicated by the Linnæan names. We have added, however, the more customary titles, in order to obviate confusion.

OF NARCOTICS.

Medicines of this class had, previous to the time of Dr. Brown, been almost universally regarded as sedative, or depressing, even in their primary operation. By a bold, and, in some measure, legitimate generalization, our author proved that this kind of agency is, in the greater number of cases, merely of a secondary nature; and that the symptoms of depressed, or, more properly speaking, exhausted power, resulting from their administration, are consequent upon the faculty they possess of exciting, in a prompt and very extraordinary manner, the actions of the system. Thus opium, which is one of the most powerful of the narcotics, Dr. Brown maintained is, in the first instance, invariably stimulant; and the same virtue he attributes to the whole range of narcotic, or, as they were formerly characterized, sedative powers.

Although this conclusion is deduced from principles in the main correct, and in its application has been of abundant service in developing the laws of organic existence, it cannot, as we have above remarked, be admitted as universal, as the fact must be obvious to all who are not biassed by system, that "the sedative effects of narcotics are often disproportioned to their previous exciting operation, allowing even in such cases for its rapidity and little permanence." Murray. This fact then, in some measure, interferes with the correctness of our author's (Mr. Murray's) classification.

Narcotics are employed medicinally with different and opposite intentions. As stimulants they are given in various disorders of debility; in intermittent and continued fever, in gout, hysteria, epilepsy, dropsy, &c. As sedatives they are administered to allay pain and irritation, and are consequently largely administered in spasmodic and painful affections.

Alcohol, ardent spirit; spirit of wine. For the origin and preparation of this consult the article ALCOHOL. The stimulant effect of alcohol is generally known to be very powerful and diffusible; its exciting power is perhaps, in proportion to its sedative quality, greater than any of the other narcotics. Moderate excitement, with proportionate subsequent languor, results from a moderate dose of spirits. In larger quantities it occasions intoxication, delirium, stupor, coma, death.

Alcohol is used externally as a stimulant in muscular pains: it has lately been discovered to be an useful application in the cure of burns. Internally it is seldom employed in medicine without dilution; and then is rather administered as an auxiliary, or solvent of other ingredients.

Ether. Ethers bear some resemblance in their medicinal powers to alcohol: they are more diffusible, and less permanent in their operation. They are employed principally in asthma, hysteria, and other spasmodic affections. Their dose is from half a drachm to one or two drachms. Externally applied, sulphuric ether has been found to relieve spasmodic contraction of the muscles, and is often useful when applied to the temples in headache.

Camphora, laurus camphora (Lin.): habitat, Japan, India. Camphor is a proximate principle of vegetables; it is principally obtained from the laurus camphora of Japan.

In a moderate dose camphor is stimulant; in a larger quantity it invariably diminishes the force of the circulation, and induces sleep.

Camphor has been used as a stimulant in typhus, cynanche maligna, and other affections attended with debi-

lity and irritation; as a sedative in pneuomonia, rheumatism, &c. In mania it has been given as an anodyne. As an antispasmodic it is employed in asthma, St. Vitus's dance, and epilepsy. Its dose is from five to twenty grains. Externally, in combination with oil or liquid opium, camphor has been advantageously used in rheumatism, bruises, and other inflammatory affections.

Papaver somniferum, poppy. Europe, Asia. The concrete juice of the capsule of this plant is opium, which is chiefly imported from Egypt, Turkey, and the East Indies.

The effects of opium, as above stated, are stimulating: it often occasions, when given in somewhat large doses, intoxication, and even actual delirium. If a larger dose be given, the symptoms of diminished action appear without any previous excitement, and are succeeded by delirium, stupor, stertorous breathing, convulsions, and death.

Where opium is given as a stimulus it ought to be administered in small and frequently repeated doses. Where the intention is to mitigate pain or irritation, it ought, on the contrary, to be given in a large dose, and at distant intervals. It is of importance to observe, that where evacuations have been previously procured, or when a state of diaphoresis is present, opium is much more genial and salutary than while the skin is dry, or the bowels torpid.

In continued, as well as intermittent, fevers, opium is given as a stimulus. In the profluviæ of Dr. Cullen, opium is employed to diminish the discharge. In gout it is highly serviceable. In convulsive and spasmodic affections it is often administered to a very great extent, as in the tetanus of warm climates. In lues venerea it is thought to accelerate the action of mercury. It is often given to promote suppuration, and is extremely efficacious in arresting gangrene. In the form of enema opium is often administered in violent affections of the bowels.

Its usual dose is one grain to an adult.

Hyoscyamus niger, indigenous, harba, semen, black henbane. This plant, in its action on the system, bears a considerable resemblance to opium; for which it is often employed as a substitute, where the latter, from idiosyncracy, occasions unpleasant symptoms. It is free from the constipating effects of opium.

Atropa belladonna, indigenous, deadly nightshade. Both the leaves and berries of this plant, and also its root, are narcotic. It is seldom used in medicine.

Aconitum napellus, aconite, monk's-hood, herba. Europe, America.

Aconite has been employed in obstinate chronic rhumatism, in schirrus, &c. Its dose is from one to two grains of the powdered leaves; of the inspissated juice half a grain.

Conium maculatum, cicuta, hemlock, folia, semen, indigenous. This is a powerful narcotic. Like the aconite, it has been used in schirrous and scrophulous affections, as well as in rhumatisms. Dose two or three grains of the powdered leaves; one or two of the inspissated juice.

Digitalis purpurea, foxglove, folia, indigenous. Of all the narcotics, digitalis most speedily and certainly diminishes the actions of the system, especially of the arteries. It acts at the same time as a stimulant on the absorbent system; hence its abundant utility in dropsy. Lately it has been extensively employed in phthisis, and in the early stages of this disorder with remarkable success. Dose one grain of the powdered leaves, and ten drops of the tincture of the Edinburgh pharmacopœia, gradually increased.

Nicotianum tabacum, tobacco, folia. America. This is a powerful narcotic. Its extreme activity prevents it from being much used in medicine.

Lactuca verosa, strong-scented lettuce, folia, indigenous.

From five to ten grains of the inspissated juice, gradually increased, have been given as a narcotic, diuretic, and antispasmodic.

Datura stramonium, thorn-apple, herba, indigenous.

This has been used in mania, epilepsy, and convulsive diseases. Dose from one to three grains of the inspissated juice.

Arnica montana, leopard's-bane, flores, radix. Germany.

The flowers have been used in the dose of five grains in palsy, convulsions, &c. Its root has been employed as a substitute for Peruvian bark.

Rhododendrum chrysanthrum, yellow-flowered rhodadendron, folia, Siberia.

This has been given in chronic rheumatism and gout.

Rhus toxicondendron, poison-oak, folia. N. America. The dried leaves have been used in palsy. Dose half a grain twice or thrice a day.

Strychnos nux vomica, vomica nut. East Indies. It has been employed in mania, hysteria, &c. Dose five grains twice a day.

Prunus lauro-cerasus, cherry-tree laurel, folia, Europe.

This has scarcely been employed in medicine.

OF ANTISPASMODICS.

Antispasmodics form a kind of intermediate class between narcotics and tonics. Spasm sometimes arises from local irritation in states of general irritability, and is sometimes occasioned by pure debility. Both narcotics therefore and tonics are used as antispasmodics; but there are certain substances which in some measure appear to possess a specific antispasmodic power; these we are now to enumerate.

Moschus, musk, moschus moschiferus. South of Asia. Musk is a peculiar substance found in a small sac, situated in the umbilicus in the male of the above animal. Its antispasmodic powers are considerable. Dose from six to twenty grains in the form of bolus: it is useful in much smaller quantities in the convulsions of infants from dentition.

Castoreum, castor, castor fiber. This is a deposition collected in cells near the extremity of the rectum in the beaver. It is much used in hysteria. Dose from ten to twenty grains.

Oleum animale empyreumaticum, empyreumatic animal oil. This is nearly discarded from practice.

Petroleum, a bitumen of a red colour. This was formerly, but is not now, much employed.

Ammonia. This, when employed alone as an antispasmodic, is given in the form of carbonate.

Ferula assafœtida, assafœtida, Persia. This is a concrete juice, obtained by incision from the roots of certain plants. Its dose, as an antispasmodic, is from five to twenty grains.

Sagapenum, gummi-resina, Persia; virtues the same as assafœtida, but inferior in power.

Bubon galbanum, gummi-resina, Africa. Dose ten grains.

Valeriana officinalis, wild valerian: radix, indigenous. This is one of the principal antispasmodics. Dose from one scruple to one drachm, three or four times a day.

Crocus sativus, saffron, indigenous. This substance is composed of the stigmata which crown the pistil of the flower. It has scarcely any virtue.

Melaleucha leucadendron, cajeput oil, India. This is scarcely in use, except as a local application in toothache.

OF TONICS.

This term ought not perhaps to be retained. The agency of tonics is not that of increasing tension or tone, but they are permanent stimulants to the living fibre. Tonics, then, are properly regarded as slow and durable, in opposition to the more diffusible and transient stimuli. They are chosen from the mineral and vegetable kingdom; the former are less speedy and sensible in their action than the latter.

From the mineral Kingdom.

Hydrargyrus, argentum vivum, mercury. *Ferrum*, iron. *Zincum*, zinc. *Cuprum*, copper. *Arsenicum*, arsenic. For the various preparations and medicinal virtues of the above important minerals, consult the articles PHARMACY and MEDICINE.

Barytes, terra ponderosa, heavy earth. This has only been used in medicine combined with muriatic acid. Dr. Crawford introduced the saturated solution into practice as a remedy for scrophula. Dose from five to twenty or more drops.

Calx, lime. This earth exists in nature as a carbonate: like barytes, it has been used as a tonic in combination with muriatic acid.

Acidum nitricum, nitric acid. This acid has been used as a tonic to support the system under a mercurial course. It has likewise been tried, but not with decided and invariable success, as a specific in the cure of lues venerea.

Oxymurias potassæ, oxymuriate of potash. This may be classed as a remedy with the former article. Its dose is, ten grains increased to twenty or twenty-five.

Tonics from the vegetable kingdom.

The tonic faculty in vegetables is intimately united with certain sensible qualities, with bitterness, astringency, and aroma. The aromatic principle is more active, but less permanent in its stimulating operation. The purest bitters independantly possess a tonic power. Astringency, when it exists exclusively, or as the most predominant principle in vegetables, constitutes a distinct class; the remaining tonics may be arranged according as bitterness or aroma is predominant.

Cinchona officinalis, cortex Peruvianus, Peruvian bark, Peru. Three kinds of this bark are in use, the pale, red, and yellow. The last is now principally employed, as it gives out more bitterness and astringency to water, alcohol, and other media. Peruvian bark was first employed in intermittent fever. In this disease it is given in the dose of a scruple or half a drachm every third hour, during the interval of the paroxysm. In continued fever it is principally employed during the latter stages. when debility is urgent. In rheumatism, erysipelas, gangrene, hæmorrhage, and almost all asthenic disorders, it has been administered as a tonic.

Cinchona Caribæa, Caribeean bark, Caribee islands. *Angustura*, Spanish West Indies. These barks have both been used as substitutes for the Peruvian.

Aristolochia serpentaria, Virginian snake-root. This is a stimulating aromatic tonic. It is generally given in the form of tincture.

Dorstenia contrayerva, contrayerva, Peru, West Indies. This is scarcely possessed of any virtue.

Croton eleutheria, cascarilla cortex, N. America. This is another substitute for Peruvian bark. Dose a scruple or half a drachm.

Colomba, radix, Ceylon, a very useful tonic bitter. Dose half a drachm.

Quassia excelsa, lignum, West Indies. This is likewise an excellent tonic. Dose, in substance, from ten to thirty grains.

Quassia simarouba, simarouba, cortex, South America. This has been extolled as a remedy in dysentery, and chronic diarrhœa. Dose a scruple.

Swietenia febrifuga, Swietenia, cortex, East Indies. *Swietenia mahagani*, mahogany. Two other proposed substitutes for the Peruvian bark.

Gentiana lutea, gentian, Switzerland, Germany. This is a common and useful remedy in dyspepsia; its virtues are extracted both by water and spirit. Dose in substance half a drachm.

Anthemis nobilis, chamomile, flores, indigenous; a powerful and well-known bitter. N. B. The following plants are now not used in medicine: *artemisia absinthium*, wormwood; *chironia centaurum*, centaury; *marrubium vulgare*, horehound; *menyanthes trifoliata*, trefoil; *centaura benedicta*, blessed thistle.

AROMATICS.

Citrus aurantium, orange, cortex flavus. The rind of the orange is principally employed as an addition to combinations of bitters used in dyspepsia. It is given in the form of tincture, conserve, and syrup.

Citrus medica, lemon, cortex fructus, Asia; similar in flavour and virtue, but rather less bitter than the orange.

Laurus cinnamomum, cinnamon, cortex, Ceylon. This is the most grateful of the aromatics.

Laurus cassia, cassia, cortex, E. Indies. This nearly resembles the cinnamon in appearance, taste, and virtue. It is therefore used with the same intention as this last. Its flavour, however, is less grateful.

Canella alba, cortex, West Indies. This is a moderately strong aromatic: it is not much used except in combination with other substances in the form of tincture.

Acorus calamus, sweet-scented flag, radix, indigenous. This is scarcely at all employed in medicine.

Ammomum zingiber, ginger, radix, East Indies. The dose of ginger is about ten grains.

Kæmpferia rotunda, zedoaria, radix, East Indies. This is seldom employed in medicine.

Santalum album, yellow sanders, lignum, E. Indies. This wood is now nearly banished from practice.

Pterocarpus santalinus, santalum rubrum, red sanders, lignum, India. This, although slightly aromatic, is at present merely used in pharmacy as a colouring ingredient.

Myristica moschata, India. Under the officinal name myristica, both nutmeg and mace are included: the former is the seed, or kernel of the fruit; the latter its capsule. Nutmeg is given as an aromatic in doses of from five to fifteen grains. In larger doses it is narcotic. Mace is employed for the same purposes as nutmeg.

Carophyllus aromaticus, clove, flores, India. Cloves are the unexpanded flowers of the plant. Dose from five to ten grains.

Capsicum annuum, capsicum, Guinea pepper, fructus, E. and W. Indies. This fruit is a very powerful stimulant. It is not in much use as a medicine. Dose from five to ten grains.

Piper nigrum, black pepper, fruit, India. Black pepper is the unripe fruit of the plant. White pepper is the ripe berry of the same vegetable, freed from its outer covering. It is milder than the black. Dose ten or fifteen grains.

Piper longum, long pepper. This is the berry of the plant, gathered before it is fully ripened. It is similar to the black pepper in its qualities.

Piper Cubeba, cubebs, the dried fruit of the tree. It has similar virtues to the other peppers.

Myrtus pimenta, Jamaica pepper, baccæ, W. Indies. This is usually called pimento; it is used in medicine principally on account of its flavour.

Amomum repens, lesser cardamom, semen. Cardamoms form an ingredient in many of the bitter tinctures.

Carum carui, caraway, semen, indigenous. These are in common use, in culinary as well as medicinal preparations.

Coriandum sativum, coriander, semen. South of Europe. These are used with the same intention as caraway.

Pimpinella anisum, anise, semen, Egypt. Anise is used chiefly in the flatulence of children. The four following seeds have similar virtues to the anise and caraway: *Anethum fœniculum*, sweet fennel, semen, indigenous. *Anethum graveolens*, dill, semen, Spain and Portugal. *Cumimum cyminum*, cumin, semen, South of Europe.

Angelica archangelica, garden angelica, semen, folia, radix. North of Europe.

Mentha piperita, peppermint, herba, indigenous. *Mentha viridis*, spear mint, herba, indigenous. *Mentha pulegium*, penny-royal, herba, indigenous. Of these three mints the first is the most pungent and carminative.

Hyssopus officinalis, hyssop, herba, Asia, South and East of Europe. This plant is nearly similar in virtues to the mints just enumerated.

OF ASTRINGENTS.

Astringents are those substances that restrain morbid evacuations. Their mode of operation has been erroneously supposed similar to that by which dead animal matter is constringed and condensed. Increased evacuations do not depend merely upon mechanical laxity of the solids; the process, therefore, by which they are arrested, cannot entirely be ascribed to chemical principles; although in some cases medicines which are employed to arrest profuse discharges, confessedly possess a power of constringing dead animal fibre. This faculty in vegetables is denominated astringency, and results from the union of gallic acid and tanning principle combined; the former, when separated, is distinguished by its property of striking a deep-black colour with the salts of iron; the other by its great attraction to animal gelatin. Vegetable astringents then may be considered as moderate permanent stimuli, modified in their action, even on living matter, by the principle above alluded to. Inordinate evacuations are, however, often restrained by mineral as well as vegetable substances, and in this case the former deserve to be arranged in the class of astringents, according to the definition above given of these powers. Dr. Darwin refers astringency to the promotion of absorption. Many agents, however, which have the greatest efficacy in exciting the absorbent vessels, are not capable of stopping hæmorrhages, or other morbid discharges.

Vegetable Astringents.

Quercus robur, oak, cortex, indigenous. This has been employed in hæmorrhage, diarrhœa, and intermittent fever. Its dose in powder is from fifteen to thirty grains.

Quercus cerris, galls, south of Europe. These are tubercles found on the branch of the tree which produces them. They are employed in medicine for the same purposes, and are used under the same forms, as oak-bark.

Tormentilla erecta, tormentil, radix, indigenous. This has been used in diarrhœa in decoction. Its dose in substance, is from half a drachm to a drachm.

Polygonum bistorta, bistort, radix, indigenous. This is a strong astringent. Dose a scruple to a drachm.

Anchusa tinctoria, alkanet, radix, South of Europe. This is at present merely employed as a colouring matter.

Hæmatoxylon Campechianum, logwood. It is used as an astringent under the form of decoction, or watery extract.

Rosa gallica, red rose, South of Europe. The principle use of this astringent is in the form of gargle.

Arbutus uva ursi, bear's wortle-berry, folia, Europe, America. This has been principally given in disorders of the urinary organs. Recently it has been proposed in phthisis pulmonalis.

Mimosa catechu, catechu, or Japan earth, East Indies. This is a powerful and useful astringent in diarrhœa. Its dose is from fifteen to thirty grains. *Kino* is employed with the same intention as catechu. Its dose is from twenty to thirty grains.

Pterocarpus draco, dragon's blood, resina, South America. This is scarcely employed in medicine.

Lacca, lac, ficus indica, resina, East Indies. Lac is very little employed as a medicinal.

Pistacea lentiscus, mastiche, resina, South of Europe. This is likewise discarded from practice.

Mineral Astringents.

The chief of these are the mineral acids, especially the sulphuric, and the compounds this acid affords with metals and earths.

Acidum sulphuricum, vitriolic acid. This is used in

hæmoptysis, menorrhagia, diabetes, hectic, &c. It is given in general in the form of diluted acid. Dose from en to thirty drops.

Argilla, argil, argillaceous earth with oxyd of iron, forming the boles of which the chief is the armenian bole, were formerly employed in, but are now rejected from, practice as nearly inert.

Supersulphas argillæ et potassæ, alum, is given in hæmorrhage, and serous evacuations. Its dose is from five to fifteen grains.

Calx, lime; calx viva, quicklime. Lime has been employed as an astringent in the form of lime-water; it is now not much used.

Carbonas calcis, carbonate of lime. The carbonates of ime are chalk (creta alba), crab's-claws (chelæ cancrorum), oyster-shells (testæ astreorum); they are rather antacids than strictly astringents.

Plumbum, lead. This, in the form of oxyd, or salts, is evidently and powerfully astringent. Its preparations that are employed are the white oxyd (cerusa, white lead), and the acetate (acetis plumbi, sugar of lead).

Zincum, zinc. The sulphate of zinc (sulphas zinci), and the acetate (acetis zinci), are both powerful astringents. The former is in principal use. It is given sometimes in dysentery, in the dose of two or three grains twice a day. In injections and collyria, it is employed in the proportion of two or three grains to an ounce of water.

Ferrum, iron. The sulphate is the most astringent preparation of iron: it is, however, oftener used as a tonic than astringent.

Cuprum, copper. The saline preparations of this metal are considerably astringent. The sulphas cupri is the most powerful. It has been employed externally as a styptic. The acetite of copper (verdigris) is used as a collyrium from its astringent styptic property.

OF EMETICS.

Emetics are very properly defined by Mr. Murray, "Substances capable of exciting vomiting, independant of any effect arising from the mere quantity of matter introduced into the stomach, or of any nauseous taste or flavour." The phenomenon of vomiting, as to its remote cause, is of a difficult explanation. It cannot be owing simply to debilitated, and consequently inverted action of the stomach from previous excitement, as a greater quantity of stimulus may be thrown into this organ without being succeeded by an inversion of its peristaltic motion. Dr. Darwin attributes the effect to a suspension of the exciting power of pleasurable sensation, in consequence of which the fibres of the stomach are arrested for a time, and at length, from the undue accumulation of irritability, their action becomes inverted. The sensation of nausea does not, however, invariably precede the act of vomiting; and even allowing this feeling to be a necessary prelude, the cause of the sensation itself is left unexplained by the sensorial theory of Dr. Darwin.

The utility of emetics under some circumstances of the system is very extensive. Their salutary effects are not solely referable to the discharge which they occasion; but they also produce other changes on the living body, both general and partial, which will be noticed in the article Medicine.

Emetics are derived from the vegetable and mineral kingdoms.

Emetics from the vegetable Kingdom.

Ipecacuanha, ipecacuan, radix, South America.

This root is the one in most general use as an emetic: it is both mild and certain in its operation. It is given in a dose from fifteen to thirty grains. Ipecacuan is employed in conjunction with opium, as a diaphoretic. In this case its dose is from three or four to ten grains.

Scilla maritima, squill, radix, South of Europe. This bulbous root of a plant growing on the sandy shores of Spain and Italy, is not at present in much use as an emetic: it is principally employed as an expectorant and diuretic.

Sinapis alba, mustard, semen, indigenous. This perhaps might have been classed among the aromatics. When employed as an emetic, its administration has been principally confined to paralytic affections. It is given in the dose of a tea-spoonful mixed with water.

Asarum Europæum, asarabacca, folia, indigenous. The introduction of ipecacuan into practice, has almost superseded the use of this powerful drug. Dose twenty grains of the dried leaves; of the dried root ten grains.

Nicotiana tabacum, tobacco.

This is a violent emetic, as well as narcotic. It is scarce ever employed in practice.

From the mineral Kingdom.

Antimonium, stibium, antimony.

Than antimony, scarcely any mineral is in more general use: it is, however, seldom used but in a state of combination with oxygen or acid. Its preparations, doses, and virtues, will be treated of under the articles Pharmacy and Medicine.

Sulphas zinc, sulphate of zinc.

This salt is sudden in its operation: it is in principal use in cases of poisons having been received into the stomach. Its dose is from ten grains to a scruple.

Sulphas cupri, sulphate of copper.

Neither this nor the acetite of copper is in much use; they are violent in their operation, and in no respect preferable to milder emetics.

OF CATHARTICS.

A discharge of the intestinal contents appears to be occasioned by medicines upon a twofold principle. Cathartics either immediately excite the fibres of the intestines, thus accelerating their peristaltic motion, and consequent fæcal evacuations, or they produce this effect more immediately by stimulating the exhalant and secerning vessels; whose fluids (the bile, pancreatic juice, and intestinal mucus) act as solvents to, and promote the discharge of, the fæces. These latter are milder in their operation than the former: they are classed by Darwin among the secernentia. There are, however, many drugs which act at the same time in each of the above modes.

Cathartics, still more than emetics, are extensively employed in medicine, as capable of operating important changes throughout the system. Their use has recently been brought more systematically into notice.

Upon the grounds just stated, cathartics may with some propriety be divided into purgative and laxative.

Purgatives.

Cassia senna, senna, folia, Egypt, Arabia. This is frequently employed: it is given in the form of infusion. Dose a drachm or more.

Rheum palmatum, rhubarb, radix, Tartary.

The best rhubarb is imported from Turkey. The China rhubarb has less of the aromatic flavour. British rhubarb is much inferior to either. The dose of rhubarb, as a cathartic, is from fifteen grains to two scruples. It is given with advantage in diarrhœa and dysentery, as it contains an astringent principle. In small doses it is stomachic and tonic.

Convolvulus jalapa, jalap, radix, Mexico. This is often administered both alone and more especially with calomel (submurias hydrargyri). Its dose is from fifteen grains to two scruples.

Helleborus niger, black hellebore, radix, Austria, Italy.

This, in a dose from ten to twenty grains, is a violent cathartic. It is seldom employed in modern practice. Dr. Mead attributed a powerful emmenagogue property to it, which however has scarcely been realized by others. The ancient physicians gave it freely in maniacal disorders.

Bryonia alba, bryony, radix, indigenous. This root is not much used. Dose from twenty to thirty grains. It is slightly diuretic.

Cucumis colocynthis, colocynth, fructus, pulpa, Syria.

A drastic purgative in a dose from three to six grains. It is seldom given by itself. It has been chiefly had recourse to in obstinate constipation.

Momordica elaterium, wild cucumber, fructus, south of Europe.

This is the most violent of all purgatives. Its dose is half a grain to two grains.

Rhamnus catharticus, buckthorn, baccarum succus, indigenous. This is seldom used.

Aloe perfoliata, socotrine, Barbadoes, or hepatic and cabbaline aloes; succus spissatus, Africa, Asia, America.

The socotrine aloes is the purest. The Barbadoes and hepatic rank next. The cabbaline is the most impure, and is the weakest. Dose from fifteen grains to a scruple. Its action is principally upon the larger intestines, and on account of the vicinity to, and sympathy of these with, the uterus, it is often useful in amenorrhœa.

Convolvulus scammonia, scammony, gummi-resina, Syria.

This is a very drastic cathartic. Dose from five to ten grains.

Gambogia gutta, gamboge, gummi-resina. East Indies.

Another violent cathartic. Dose from one to four or five grains. In conjunction with the last and following article gamboge is often administered in dropsy.

Submurias hydrargyri, mild muriate or mercury, calomel.

Dose from five to eight or ten grains.

Laxatives.

Manna, manna, fraxinus ornus, succus concretus, South of Europe.

This is a mild and pleasant laxative. It is frequently given to children in conjunction with senna. Dose to an adult from one to two ounces.

Cassia fistula, purging cassia, or cassia in the pod; pulpa fructus, Egypt, East and West Indies.

Dose from four to six drachms.

Tamarindus Indica, tamarind, fructus conditus, E. and W. Indies, America, Arabia.

The tamarinds of the shops is the pulp of the tree mixed with seeds and small fibres, with a quantity of coarse sugar.

It may be taken to the extent of two ounces, or more.

Ricinus communis, palma Christi, oleum, semen, W. Indies.

The oil from the nuts of palma Christi is the castor oil of the shops. This is a mild and very useful purgative.

Sulphur, a simple inflammable substance, and *magnesia*, either pure or carbonated, are all the laxitives that are afforded by the mineral kingdom. The operation of either is exceedingly mild.

For the different neutral salts that are employed as purgatives in medicine, see PHARMACY.

The purgatives that are administered only in the form of enema, are the

Murias sodæ, common salt. An ounce of this dissolved in a pint of tepid water with an ounce of expressed oil, forms the common domestic enema.

Terebinthina veneta, turpentine, pinus larix, gummiresina. This is sometimes employed as an enema triturated with the yolk of an egg. Dr. Cullen recommends this as a very certain cathartic. It is indicated in obstinate costiveness.

Nicotiana. The introduction per-ano of tobacco smoke has sometimes been effectual in procuring alvine evacuation, after other cathartics have failed. The infusion of from one to two drachms in a pint of water is a more convenient mode of administering this medicine. Much caution is requisite in either case to obviate its depressing effects.

OF EMMENAGOGUES.

These are medicines which promote the menstrual discharge. Obstruction or retention of the menses, unless consequent upon defective conformation, or uterine impregnation, is usually owing to weakness or want of due excitation in the vessels of the uterus.

This debility is best overcome by general stimulating and tonic agents, which thus acting, become emmenagogues; sometimes, however, it is necessary more immediately and directly to excite the parts in the vicinity of the uterus, by such purgatives whose action is principally directed to the inferior portion of the intestinal canal. In this case these cathartics prove emmenagogues, but not, as was formerly conjectured, by virtue of any specific power.

Emmenagogues from the class of tonics.

Ferrum, the carbonate of iron, rubigo ferri præparata; is given in a dose of ten or fifteen grains in amenorrhœa; the sulphate of iron in three or four grains. This last is the ferrum vitriolatum of the London pharmacopœa.

Hydrargyrus, the mild muriate of mercury, as already noticed.

Cinchona. This is frequently given in amenorrhœa, in conjunction with some of the preparations of iron.

From the class of antispasmodics.

Castoreum. This is a medicine of very trifling efficacy when used as an emmenagogue. Dose from ten to twenty grains.

Ferula assafœtida, and the other fœtid gums, (galba-

num, sagapenum, and ammoniacum) are employed sometimes as emmenagogues. Dose from ten grains to fifteen.

From the class of cathartics.

Aloes. This substance is generally connected with others when given to promote the menses, as in the pilula aloes cum myrrha, &c.

Helleborus niger. This is not at present in much repute. Dose of the extract from three to ten grains.

Sinapis alba, semen, mustard-seed in the dose of about half an ounce is sometimes taken as an emmenagogue.

Rosmarinus officinalis, rosemary, summitales florentis. This is now nearly banished from practice.

Rubia tinctorum, madder, radix, south of Europe. Dose from a scruple to half a drachm. Its virtues are not much confided in by modern physicians.

Rutea graveolens, ruta, rue, herba, south of Europe. The herb in the form of infusion, and likewise its essential oil, are the preparations of rue that are given. It is perhaps of inferior efficacy.

Juniperus sabina, savin, folia, south of Europe. Savin is not much used internally, although supposed by some to be a powerful emmenagogue.

OF DIURETICS.

Diuretics are those medicines which augment the urinary discharge. This effect is either produced by a direct stimulus communicated to the kidneys, by a sympathetic excitement of these organs from a previous action excited in the stomach, or lastly, by the promotion of absorption, by which more than their usual quantity is directed to the secretory vessels of the urine. The saline diaphoretics seem principally to exert their agency in the first of these ways. Squill and others appear to produce a primary action of the stomach, and digitalis from its extraordinary power over the absorbent system is an example of the last-mentioned mode of procuring diuresis.

Saline diuretics.

Supertartris potassæ, cream of tartar. Dose four or six drachms twice a day in a considerable quantity of water. This has been much employed in dropsy.

Nitras potassæ nitre. Dose from five to twenty grains. Nitre was formerly much used in gonorrhœ, in order to abate the ardor urinæ.

Murias ammoniæ, crude sal ammoniac. This is not much employed. Dose from eight grains to a scruple.

Acetis potassæ, sal diureticus. This has now likewise fallen into disuse.

Potassa, kali. The dose of carbonated kali is from twenty to thirty grains.

Vegetable diuretics.

Scilla maritima. Dose as a diuretic from one to three or four grains.

Digitalis purpurea. Dose from one grain to two or more, of the powdered leaves: from ten to thirty drops of the saturated tincture. The dose requires to be regulated and increased with much caution.

Nicotiana tabacum. An ounce of the dried leaves infused in a pint of water, has been given as a diuretic in the dose of from sixty to a hundred drops.

Solanum dulcamara, woody nightshade, bitter, sweet, indigenous. This is scarcely ever prescribed.

Lactuca verosa. Dose from ten grains to three drachms. It is not much used.

Colchium autumnale, meadow saffron, indigenous. This has not been in much use in this country. It was first prescribed in dropsy by Stork of Vienna.

Gratiola officinalis, hedge hyssop, south of Europe. The leaves of this plant have likewise been given in dropsy, but they have not come into general use.

Spartium scoparium, broom, summitales, indigenous.

The broom tops infused in water have proved advantageous in dropsy.

Juniperus communis, juniper, baccæ, indigenous. Juniper berries given in infusion have a pretty considerable diuretic power.

Copaifera officinalis, copaiva balsam, South America. Dose from twenty to thirty drops twice a day. It is principally employed in gleet.

Pinus larix, Venice turpentine, balsamum. Dose from five to twelve drops of the essential oil. This has likewise been given in gleet, and in ichias.

Pistachia terebinthinus, Cyprus turpentine. This is more fragrant than the balsam from the pinus; as is likewise Strasburgh turpentine, the produce of the pinus picea. The common turpentine (pinus sylvestris balsam) is on the other hand the most offensive.

Diuretics from the animal Kingdom.

Meloe vesicatorius, cantharides, Spanish fly. This is an insect collected from the leaves of plants growing in the South of Europe. It has principally been given internally for gleet and retention of urine. Dose one grain gradually increased.

OF DIAPHORETICS.

If the natural and constant exhalation from the skin be condensed on the surface from its augmented discharge, it constitutes sweat. This effect when produced only to a certain extent, is called diaphoresis. Diaphoretic and sudorific powers differ then only in degree. Diaphoretics are classed by Darwin under the head of secernentia. They necessarily operate by directly or indirectly exciting the cutaneous exhalants. The saline and cooling diaphoretics appear to act in the latter, the heating medicinals which are given to procure sweat in the former manner. Diaphoretics with respect to their influence on the system, are often abundantly powerful and salutary.

Ammonia. All saline preparations are more or less diaphoretic under proper regulation. The ammoniacal salts have been imagined to be so in a greater degree than others. See PHARMACY.

Hydrargyrus. The mild muriate (calomel) in conjunction with opium in very small doses, is sometimes usefully employed as a diaphoretic.

Antimonium. All the preparations of antimony may be made to prove sudorific.

Ipecacuanha. In a dose of two or three grains with or without an opiate.

Opium. This when employed as a diaphoretic is generally combined with one or other of the three former medicines.

Camphor likewise must be united with mercury, antimony, or opium, when it is intended as a diaphoretic.

Guaiacum officinale, guaiac lignum, et gummi-resina, South America, and the West Indies. Guaiac wood is

given in the form of decoction, a quart of which is given in the course of the day. The gum-resin is commonly administered in spirit of ammonia, from which it derives a considerable part of its virtues. Dose from one drachm to two of the tincture.

Daphne mezereum, mezereon, cortex radicis, indigenous. This is a stimulating diaphoretic: it is generally given in lues venerea, with sarsaparilla, and guaiac, forming the Lisbon diet-drink.

Smilax sarsaparilla, radix, South America. This has scarcely any power exclusively employed.

Lauras sassafras, sassafras, lignum, America. This is slightly stimulant and diaphoretic. It is probably less efficacious than has generally been imagined.

Cachlearia armoracia, horse-radish, radix, indigenous. This is a stimulant capable of promoting perspiration. About a drachm of the root cut in small pieces and swallowed whole, has been recommended in paralysis, rhumatism, asthma, and dropsy.

Salvia officinalis, sage, folia, south of Europe. Its aqueous infusion drunk warm is slightly stimulant and diaphoretic.

EXPECTORANTS

Are those medicines which facilitate the rejection of mucus or other fluids from the lungs. This object is accomplished by increasing pulmonary exhalation where deficient, or diminishing it when too copious. In the one instance expectorants are secernent, in the other absorbent powers: their operation, like that of emetics, is in both cases either direct or indirect.

Antimonium. The most common preparation of antimony for an expectorant is the emetic tartar of the shops. This is given in pneumonia, catarrh, hooping cough, and asthma, in the dose of one eighth of a grain. It is generally combined with opiates in mucilaginous mixtures, and in this way is more efficacious.

Ipecacuanha. It is given with the same intention in a dose of two or three grains.

Digitalis, in the dose of half a grain, has been used as an expectorant, as likewise

Nicotiana, in the dose of one, two, or three grains.

Scilla. This is one of the most effectual of the expectorantia. Dose one grain of the dried root.

Allium sativum, garlic, radix, south of Europe. Garlic is given in humoral asthma, dropsy, &c. in the dose of half a drachm or two scruples.

Polygala senega, seneka, radix, North America. Dose from ten grains to a scruple. It is chiefly employed in the secondary stage of pneumonia.

Ammoniacum, ammoniac, East Indies, gummi-resina. Dose from ten to thirty grains. This is frequently used as an expectorant.

Assafœtida. Dose from ten to twenty grains.

Myrrha, myrrh, gummi-resina, Abyssinia and Arabia. Dose from ten to twenty grains.

N. B. The plants producing the above two gum-resins are unknown.

Styrax benzoin, benzoir or Benjamin, balsamum, East Indies. Dose ten or fifteen grains. It is perhaps possessed of little power.

Styrax officinale, storax, bals. south of Europe, Asia. Storax is like benzoin in its virtues.

Toluifera balsamum, balsam of tolu, South America. The powers of this balsam are very inconsiderable.

Myroxolon peruiferum, Peruvian balsam, South America. Dose in asthma, leucorrhœa, &c. from five to fifteen grains.

Amyris gileadensis, balm of Gilead, Arabia. The qualities of this nearly resemble the balsam of tolu.

OF SIALAGOGUES.

These are substances which increase the secretion of saliva. This is in general effected by mastication of acrid substances, but in some few instances is occasioned by medicines taken into the stomach. Mercury, perhaps, is the only medicine which uniformly displays a sialagogue power.

Hydrarrgyrus. All the preparations of mercury have more or less influence over the salivary glands.

Anthemis pyretrum, pellitory of Spain, radix, south of Europe. This is sometimes chewed in order to relieve the tooth-ache.

Arum macnlatum, wake-Robin, radix, indigenous. This resembles pellitory, and may be employed with the same intention.

Ginger, mezereum, and tobacco especially, are sometimes used as sialagogues.

ERRHINES

Are medicines which occasion a more than ordinary secretion from the mucous membrane of the nostrils. They all operate by direct application.

Iris florentina, Florentine orris, radix, south of Europe. This is a mild sternutatory and forms one of the ingredients of some cephalic snuffs.

Æsculus hippocastinum, horse chesnut, semen. This acts as a moderate sternutatory.

Origanum majorana, sweet marjorum, herba, south of Europe. This has a slight errhine power.

Lavandula spica, lavender, spicæ florentes, south of Europe. The dried leaves in powder.

Nicotiana, tobacco. The powder of the dried leaves is the basis of snuffs.

Asarum Europœum, asarabaca, folia, indigenous. The leaves of this plant in powder form the basis of officinal sternutatory powders.

Veratram album, white hellebore, radix, south of Europe. This is a very violent errhine.

Euphorbia officinalis, gummi-resina, Africa. This is the most powerful of all the errhines. It is seldom or never employed.

Subsulphus hydrargyri. This preparation of mercury has been recommended to be snuffed up the nostrils in some kinds of chronic ophthalmia.

EPISPASTICS AND RUBEFACIANTS.

Epispastics are those substances which applied to the skin produce either serous or purulent discharge through the medium of inflammation. Rubefaciants occasion inflamation, but not so violent as to be followed by such discharges.

Meloe vesicatorius, cantharis, Spanish fly. This is the principal substance employed for blistering. After a blister has been raised the discharge is often converted from serum into pus by the continued application of any

stimulating acid ointment. This practice is often pursued in asthma, paralysis, &c.

Cantharides in the form of tincture may be employed simply as a rubefaciant.

Ammonia with oil, forms a liniment for this purpose.

Pinus albus, Burgundy pitch, resina. This is used in the form of plaster, in chronic affections of the lungs and chest.

Sinapis, mustard. The flour of mustard-seed mixed with crumbs of bread, and made into a paste with vinegar, forms a sinapism, a powerful rubefacient. It is applied to the soles of the feet in cases of pressing debility, as in the last stages typhoid fever, and in comatose affections.

Allium, garlick. The bruised root of this plant is used for similar purposes with the mustard sinapism.

OF REFRIGERANTS.

Mr. Murray considers those medicines which directly lower the temperature of the body, to be principally chemical in their operation. They are acids, or substances containing a superabundant proportion of oxygen, which being received into the stomach, occasions a less demand for this principle (oxygen) by the lungs, and consequently a less generation or evolution of heat. This doctrine, however, does not appear satisfactory. See PHYSIOLOGY, Sections *Digestion* and *Respiration;* and MEDICINE, Section *Fever*, &c.

Of refringerants, the vegetable acids are the most efficacious.

Citrus aurantium, orange, succus fructus. The acidity of China orange is connected with sweetness, of the orange from Serville with bitterness. The former is used as a refrigerant in fever.

Citrus medica, lemon, succus fructus. The juice of the lemon is composed of citric acid, and saccharine and mucilaginous matter. It is the most powerful and agreeable of the refrigerants. With carbonate of potass, (kali prep.) it forms the saline draught, the virtues of which are perhaps owing to the carbonic acid that is evolved by the mixture of the acid and alkali.

Tamarindus indica. Tamarind is a very pleasant refrigerant: a solution of it in water constitutes a pleasant beverage in fever.

Acidum acetosum, vinegar. The use of this in medicine is principally as a substitute for the lemon-juice.

Supertartris potassæ, cream of tartar.

Nitras potassæ. This is given as a refrigerant, in a dose of from five grains to a scruple.

ANTACIDS.

These perhaps are more strictly chemical in their primary operation than the last class of medicines. They immediately neutralise the prevailing morbid acidity of the stomach.

Alkalies. Pure potass in solution is employed to correct acidity, in doses of fifteen drops in water. The carbonates of potass and soda are, however, in more general use for this purpose.

Aqua ammoniæ is given likewise with this intent. Dose from twenty to forty drops.

Aqua calcis. Lime-water is also used to correct acidity; six or eight ounces being taken occasionally.

Carbonas calcis. Of this there are two varieties, creta alba, (prepared chalk) and chelæ cancrorum (crab's claws). These, especially the former, are principally used in the diarrhœa of infants.

Magnesia (carbonas magnesiæ). This is in some cases preferable to chalk as an antacid, as the neutral compound formed by its union with the acid of the stomach proves slightly purgative.

OF LITHONTRIPTICS,

Medicines supposed to have a power of dissolving stone in the bladder. Calculus is principally formed by a peculiar acid, called the lithic, or uric, with which alkalies unite out of the body, and thus become solvents of the stone. These medicines, however, cannot in any way be conveyed to the urinary organs in sufficient quantity to effect this purpose, without material injury to the parts and the general system. It has indeed been ascertained, from experiment, that by the exhibition of alkaline substances, for a length of time, the constitutional disposition to secrete fresh caculus is in a great measure obviated. These substances then are rather preventives than curatives of calculary disorders. That they do not, when taken into the stomach, operate as solvents, is sufficiently evident, from the circumstance of their being more useful when administered saturated with carbonic acid; for these alkaline carbonates do not exert any action on the urinary calculi out of the body, as the lithic acid of the concretion is not of sufficient attractive power to disengage the carbonic acid from its union with the salt. The only power then that is possessed by the medicines termed lithontriptics, is that of neutralizing acidity in the first pasages, and thus preventing the deposition of lithic acid in the urinary organs.

Potassa, potass. The dose of the solution of pure potass is 15 or 20 drops gradually increased. The form in which it is generally employed as a lithontriptic, is in the supersaturated solution. Dose, one or two pounds daily.

Soda. This is likewise used in the form of saturated solution, under the name of soda water. Dose, one or two pounds.

Sapo albus. Soap is a combination of expressed oil with potass or soda. Dose, one or two ounces in the course of the day.

Calx. Lime-water is sometimes employed as a lithontriptic.

ESCHAROTICS

Are substances which destroy the texture of both living and dead animal matter. They are employed to consume excrescences, or to open ulcer. Their action on the living system is principally, but not entirely, chemical.

The mineral acids have been employed as escharotics, but are not convenient, in consequence of their fluidity.

Potassa, in its solid state, is a powerful escharotic: mixed with lime it is somewhat milder.

Nitras argenti. Lunar caustic. This is in common use.

Murias antimonii. A powerful caustic, but inconvenient from its being in a fluid form.

Sulphas cupri is often employed.

Acetis cupri. (Verdigris.) This is milder than the sulphate.

Murias hydrargyri. Principally used in the venereal ulcers.

Subnitras hydrargyri. Employed with the same intention as the muriate.

Oxydum arsenici albi. A solution of white arsenic is sometimes made use of as an external application to cancer.

Juniperus sabina. Savine is principally applied in the form of ointment to obstinate ulcers. It is used in powder to consume warts.

ANTHELMINTICS

Are those medicines employed to expel worms from the intestinal canal. Their operation is supposed to be different. Some acting mechanically by the sharpness or roughness of their particles, as filings of tin, cowhage, &c. Others prove noxious to these animals from their poisonous and narcotic properties, or expel them by simply evacuating the bowels, as pink root, worm seed, gamboge, calomel, &c.

Dolichos pruriens, cowhage, East and West Indies. This substance is the down growing on the pods of the plant. The action of this medicine may perhaps be principally mechanical.

Ferrum, iron. The filings and rust.

Stannum, tin. This is used in the form of powder. Tin may perhaps operate by a mechanical power. Dose, one or two drachms.

Olea Europœa, olive oil, oleum expressum, South of Europe. Dose half a pound.

Artemisia santonica, worm seed, Persia. Dose half a drachm.

Spigelia marilandica, Indian pink, radix, North America. Dose half a drachm.

Polypodium filix mas, male fern, radix, indigenous. Dose two or three drachms.

Tanacetum vulgare, tansy, folia et flores, indigenous. Dose from a scruple to a drachm.

Geoffula inermis, cabbage bark-tree, cortex, Jamaica. Dose thirty grains.

Gambogia. Dose from five to twenty grains.

Submurias hydrargyri. Calomel is perhaps the most efficacious of all the anthelmintics. Dose ten or twelve grains to an adult.

DEMULCENTS

Are substances employed in medicine to shield from acrimony; they can only act on the parts to which they are directly applied. From some circumstances, however, attending their internal administration, it is supposed that they are capable of being absorbed and again separated by particular secretory organs. This supposition does not appear to be entirely satisfactory.

Mimosa nilotica, gum arabic, Africa. This is used to allay the irritation of the fauces in catarrh. It is likewise given in tenesmus, strangury, &c.

Astragalus tragacantha. tragacanth, South of Europe, Asia. This has virtues similar to gum arabic. It is more viscid.

Linum usitatissimum, flax, semen, indigenous. This is sometimes used in gonorrhœa, and catarrh.

Althæa officinalis, marsh mallow, radix, indigenous.

Malva sylvestris, common mallow, folia, indigenous.

Glycyrrhiza glabra, liquorice, radix, South of Europe. These three last are all pleasant demulcents.

Cycas circinalis, sago, East Indies. This is a fæcula from the pith of the plant; it is often given in dysentery, &c. as demulcent and at the same time nutritive.

Orchis mascula, salop, indigenous. Similar in virtue to sago.

Maranta arundinacea, South America. Arrow-root is demulcent, and slightly nutritive.

Tryticum hybernum, wheat, amylum. Starch is useful as an enema with opium in dysentery, &c.

Cornu cervi rasura, hartshorn shavings.

Icthyocolla, isinglass is obtained from the skin of the fish. Isinglass is a demulcent in frequent use.

Olea olivæ. The expressed oil principally used as a demulcent is obtained from the fruit of the olive.

Amygdalus communis, almond oil. Ol. express. South of Europe.

Sævum ceti. Spermaceti is obtained from the head of a certain species of whale. Like the almond oil, it is given as a demulcent in catarrh, &c.

Cera, wax. This is collected from the antheræ of vegetables by bees. This is particularly employed in the composition of ointments and plasters.

Of diluents and emollients the two remaining classes scarcely any thing remains to be said. Water, strictly speaking, is the only diluent, and emollients are chiefly formed of heat combined with moisture, as in formations and cataplasms; or of unctuous substances, as lard (axungia porcina) and the varieties of expressed oils.

MATHEMATICAL INSTRUMENTS. See INSTRUMENTS.

MATHEMATICS, from μαθησις, originally signified any discipline or learning; but at present denotes that science which teaches or contemplates whatever is capable of being numbered or measured, in so far as computable or measurable, and accordingly is subdivided into arithmetic, which has number for its object, and geometry, which treats of magnitude. See ARITHMETIC, and GEOMETRY.

Mathematics are commonly distinguished into pure and speculative, which consider quantity abstractedly; and mixed, which treat of magnitude as subsisting in material bodies, and consequently are interwoven every where with physical considerations.

Mixed mathematics are very comprehensive; since to them may be referred astronomy, optics, geography, hydrostatics, mechanics, fortification, navigation, &c. See ASTRONOMY, OPTICS, &c.

Pure mathematics have one peculiar advantage, that they occasion no disputes among wrangling disputants, as in other branches of knowledge; and the reason is, because the definitions of the terms are premised, and every body that reads a proposition has the same idea of every part of it. Hence it is easy to put an end to all mathematical controversies, by showing either that our adversary has not stuck to his definitions, or has not laid down true premises; or else that he has drawn false conclusions from true principles; and in case we are able to do neither of these, we must acknowledge the truth of what he has proved.

It is true, that in mixed mathematics, where we reason mathematically upon physical subjects, we cannot give such just definitions as the geometricians; we must therefore rest content with descriptions, and they will be of the same use as definitions, provided we are consis-

MAX

principles, which appear essentially different from each other, and which have never yet been brought to a more simple form. Thus the matter of fire, or light, appears totally different from that of all other bodies; thus the acid and alkaline principles can never be brought to exhibit the same properties; nor can even the different species of earths be converted into the substance of each other.

If hypothetical reasoning was to be admitted on this occasion, it would probably appear more agreeable to the analogy of nature, to suppose that different substances are formed from the different combinations of a few simple principles in different proportions, than that the very opposite qualities of some of the rarest and most subtile fluids should depend wholly on the different form or modification of the extremely minute particles which enter into their composition.

It is proper, however, to observe, that on this subject there has hitherto appeared no decisive experimental proof on either side. The imperfection of all human efforts, and perhaps of the human faculties themselves, has hitherto confined our investigations to the properties of a few substances, the simplest which chemical analysis has been able to obtain, and which for that reason are denominated elements. See Elements.

MATTUSCHKÆA, a genus of the tetrandria monogynia class and order. The calyx is four-parted; corolla one-petalled; germ superior, four-cleft. There is one species, a herb of Guiana.

MAURITIA, the *ginkgo* or *maiden hair*, a genus of plants belonging to the natural order of palmæ. The calyx of the male is monophyllous; the corolla monopetalous, with six stamina. It is a native of Japan, where it is also known by the names of ginan and itsio. It rises with a long, erect, thick, and branched stem to the size of a walnut-tree. The bark is ash-coloured, the wood brittle or smooth, the pith soft and fungous. The leaves are large, expanded from a narrow bottom into the figure of a maiden-hair leaf, unequally parted, streaked, without fibres or nerves. From the uppermost shoots hang the flowers in long catkins that are filled with the fertilizing power; and to which succeeds the fruit, adhering to a thick fleshy pedicle, which proceeds from the bosom of the leaves. This fruit is either exactly or nearly round, and of the appearance and size of a damask plum. The substance surrounding the fruit is fleshy juice, white, very harsh, and adheres so firmly to the inclosed nut, as not to be separated from it except by putrefaction. The nut, properly termed gineau, resembles the pistachia nut, especially a Persian species named bergjes pistoia; but is almost double in size, and of the figure of an apricot-stone. The shell is somewhat white, woody, and brittle, and incloses a white loose kernel, having the sweetness of an almond, along with a degree of harshness. These kernels taken after dinner are said to promote digestion, whence they make part of the dessert in great entertainments.

MAXILLA. See Anatomy.

MAXIMUM, in mathematics, denotes the greatest quantity attainable in any given case. If a quantity conceived to be generated by motion, increases, or decreases, till it arrives at a certain magnitude or position, and then, on the contrary, grows less or greater, and it be required to determine the said magnitude or position, the question is called a problem de maximis et minimis.

Thus, let a point m move uniformly in a right line, from A towards B, and let another point n move after it, with a velocity either increasing or decreasing, but so that it may, at a certain position D, become equal to that of the former point m, moving uniformly.

$$\begin{array}{ccccccc} & & D & & C & & \\ A & \text{———————} & + & \text{———————} & + & \text{———————} & B. \\ & & n & & m & & \end{array}$$

This being premised, let the motion of n be first considered as an increasing one; in which case the distance of n behind m will continually increase, till the two points arrive at the contemporary positions C and D; but afterwards it will again decrease; for the motion of n till then being slower than at D, it is also slower than that of the preceding point m (by the hypothesis), but becoming quicker afterwards than that of m, the distance $m\,n$ (as has been already said) will again decrease; and therefore is a maximum, or the greatest of all, when the celerities of the two points are equal to each other.

But if n arrives at D with a decreasing celerity, then its motion being first swifter, and afterwards slower, than that of m, the distance $m\ n$ will first decrease and then increase, and therefore is a minimum, or the least of all, in the forementioned circumstance. Since then the distance $m\,n$ is a maximum, or a minimum, when the velocities of m and n are equal, or when that distance increases as fast through the motion of m as it decreases by that of n, its fluxion at that instant is evidently equal to nothing. Therefore, as the motion of the points m and n may be conceived such that their distance $m\,n$ may express the measure of any variable quantity whatever, it follows, that the fluxion of any variable quantity whatever, when a maximum or a minimum, is equal to nothing.

The rule therefore to determine any flowing quantity in an equation proposed, to an extreme value, is: having put the equation into fluxions, let the fluxion of that quantity whose extreme value is sought be supposed equal to nothing; by which means all those members of the equation in which it is found will vanish, and the remaining ones will give the determination of the maximum or minimum required.

Prob. I. To divide a given right line into two such parts, that their product, or rectangle, may be the greatest possible. This is the case when the line is bisected or divided into equal parts. See Fluxions.

In any mechanical engine the proportion of the power to the weight, when they balance each other, is found by supposing the engine to move, and reducing their velocities to the respective directions in which they act; for the inverse ratio of those velocities is that of the power to the weight according to the general principle of mechanics. But it is of use to determine likewise the proportion they ought to bear to each other, that when the power prevails, and the engine is in motion, it may produce the greatest effect in a given time. When the power prevails, the weight moves at first with an accelerated motion; and when the velocity of the power is invariable, its action upon the weight decreases, while the velocity of the weight increases. Thus the action of a stream of water or air upon a wheel, is to be estimated from the

tent with ourselves, and always mean the same thing by those terms we have once explained.

MATHIOLA, a genus of the pentandria monogynia class and order. The calyx is entire; corolla tubular, superior, undivided, drupe with a globular nucleus. There is one species, American.

MATRICARIA, *feverfew*, a genus of the polygamia superflua order, in the syngenesia class of plants, and in the natural method ranking under the 49th order, compositæ. The receptacle is naked; there is no pappus; the calyx hemispherical and imbricated, with the marginal leaflets solid, and something sharp. There are eight species, but the only remarkable one is the parthenium or common feverfew, of which there are varieties with double flowers, with semi-double flowers, with double fistular disk and plain radius with short-rayed flowers, with rayless flowers, with rayless sulphur-coloured heads, and with finely curled leaves. All these varieties flower abundantly in June, each flower being composed of numerous hermaphrodite and female florets; the former compose the disk, the latter the radius or border, and which, in the double and fistulous kinds, are very ornamental in gardens, but of a disagreeable odour; and are all succeeded by plenty of seed in autumn. This plant has received a most extraordinary character in hysteric and other affections of the nerves, as well as for being a carminative or warm stimulating bitter. Dr. Lewis, however, thinks it inferior to camomile; with which he says it agrees in all its sensible qualities, only being somewhat weaker.

MATRICE, or MATRIX, in dyeing, is applied to the five simple colours, whence all the rest are derived or composed. These are, the black, white, blue, red, and yellow or root-colour. See DYEING.

MATRICE, or *matrices*, used by the letter-founders. See TYPE.

MATRICES. See COINING.

MATRIX, or MOTHER EARTH, the stone in which metallic ores are found enveloped.

MATROSSES, are soldiers in the train of artillery, who are next to the gunners, and assist them in loading, firing, and spunging the great guns. They carry firelocks, and march along with the store-waggons both as a guard, and to give their assistance in case a waggon should break down.

MATT, in a ship, rope-yarn, junk, &c. beaten flat and interwoven; used in order to preserve the yards from galling or rubbing in hoisting or lowering them.

MATTER. The word matter (materia, which some lexicographers have derived from mater, a mother) denotes, in its primitive sense, that unexplained something from which all those things which are objects of our senses are formed.

The term body is sometimes confounded with that of matter; but they are essentially different. Body is of Saxon origin. It is explained by the Latin words statura, pectus, truncus; and signified the person or form of a man, or other creature; whence it is plain that it ought to be confined to express a substance possessing form or figure.

Substance, both in its etymology and application, approaches nearer to the meaning of the former of these terms. It is well known to be compounded from the Latin preposition sub (under) and the verb stare (to stand). It consequently implies that which supports or stands under the different forms and appearances which are presented to our senses. It is still, however, used in a distinct and more limited sense than matter. It is generally indeed used with the article, to signify a distinct or definite portion of matter; whereas matter in the abstract implies a more confused and general idea of solidity and extension, with little or no regard to figure, proportion, or quantity.

That the whole matter of which this universe of things is composed, is essentially the same, and that the apparent differences which subsist in different bodies depend altogether on the particular distribution or disposition of the component particles, is an opinion which has been entertained by some philosophers of the highest reputation. The wonderful apparent transmutations which take place in the different processes and operations of nature do, it must be confessed, at first sight countenance this hypothesis. A plant will vegetate, and become a solid substance, in the purest water. The generation of stones in the earth, the various phenomena of petrifactions, and a multitude of other facts, contribute greatly, on a fair consideration, to diminish the absurdity of the alchemists (who seem chiefly to have rested on this hypothesis, viz. that all matter was intrinsically the same) and their hopes of converting the basest materials by the efforts of art into the most splendid and valuable of substances.

Mr. Boyle distilled the same water about two hundred times, and at the end of each distillation found a fresh deposit of earth. Margraff repeated the experiment with still greater caution. By means of two glass globes, which communicated with each other, he preserved the water while in the state of vapour from all contact with the air; and on repeated distillation, a quantity of earth of the calcareous kind was deposited at the conclusion of each process.

The extreme rarity and minuteness of the particles into which different substances may be resolved, imparts a still greater degree of probability to this hypothesis: and in general the more any body can be divided, the simpler it appears in its component parts.

We must, however, be cautious of admitting opinions which are not sanctioned by the direct test of experiment; and however plausible the opinion, the accurate observations of modern philosophy have suggested some objections to the homogenity of matter, which, without further discoveries, it will not be easy to silence.

Whatever phenomena may appear to indicate a transmutation of bodies, or a change of one substance into another, we have the utmost reason, by the latest and best experiments, to believe them merely the effect of different combinations. Thus the conversion of water and air into a solid substance, such as the body of a plant, is merely an apparent conversion; for that solid substance may, by an artificial process, be resolved again into water and air, without any real change in the principles or elementary particles of which those fluids are composed: and the formation of stones, and the phenomena of petrifactions, are accounted for upon much easier principles than that of transmutation. On the other hand, the utmost efforts of chemistry have never been able to proceed farther in the analysis of bodies than to reduce them to a few

excess of the velocity of the fluid above the velocity of the part of the engine which strikes, or from their relative velocity only. The motion of the engine ceases to be accelerated when this relative velocity is so far diminished, that the action of the power becomes equal to the resistance of the engine arising from the gravity of the matter that is elevated by it, and from friction; for when these balance each other, the engine proceeds with the uniform motion it has acquired.

Prob. II. Let a denote the velocity of the stream, u the velocity of the part of the engine which it strikes when the motion of the machine is uniform, and $a-u$ will represent their relative velocity. Let A represent the weight which would balance the force of the stream when its velocity is a, and p the weight which would balance the force of the same stream if its velocity was only $a-u$; then $p : A :: \overline{a-u}^2 : a^2$, or $p = A \times \frac{\overline{a-u}^2}{aa}$, and p shall represent the action of the stream upon the wheel. If we abstract the friction, and have regard to the quantity of the weight only, let it be equal to qA, (or be to A as q to 1); and because the motion of the machine is supposed uniform, $p = q \times A = \frac{A \times \overline{a-u}^2}{aa}$, or $q = \frac{\overline{a-u}^2}{aa}$. The momentum of this weight is $qAu = \frac{Au \times \overline{a-u}^2}{aa}$; which is a maximum when the fluxion of $\frac{u \times \overline{a-u}^2}{aa}$ vanishes, that is, when $u \times \overline{a-u}^2 - 2uu \times \overline{a-u} = 0$, or $a - 3u = 0$. Therefore, in this case, the machine will have the greatest effect if $u = \frac{a}{3}$, or the weight $qA = \frac{A \times \overline{a = u}^2}{aa} = \frac{4A}{9}$; that is, if the weight that is raised by the engine be less than the weight which would balance the power in the proportion of 4 to 9: and the momentum of the weight is $\frac{4Aa}{27}$.

Prob. III. Suppose that the given weight P (plate XCIV. Miscel. fig. 156.) descending by its gravity in the vertical line, raises a given weight W by the cord PMW (that passes over the pulley M) along the inclined plane BD, the height of which BA is given; and let the position of the plane BD be required, along which W will be raised in the least time from the horizontal line AD to B.

Let $AB = a$, $BD = x$, $t =$ time in which W describes DB; then the force which accelerates the motion of W is $P - \frac{aW}{x}$, tt is as $\frac{xx}{Px - aW}$, and if we suppose the fluxion of this quantity to vanish, we shall find $x = \frac{2aW}{P}$, or $P = \frac{2aW}{x}$; consequently the plane BD required is that upon which a weight equal to 2W would be sustained by P; or if BC be the plane upon which W would sustain P, then $BD = 2BC$. But if the position of the plane BD be given, and W being supposed variable, it be required to find the ratio of W to P, when the greatest momentum is produced in W along the given plane BD; in this case, W ought to be to P as BD to $BA + \sqrt{\overline{BD} + \overline{BA}} + \sqrt{BA}$.

Questions of this kind may be likewise demonstrated from the common elementary geometry, of which the following may serve as an example.

Prob. IV. Let a fluid, moving with the velocity and direction AC (plate XCIV. Miscel. fig 157), strike the plane CE; and suppose that this plane moves parallel to itself in the direction CB, perpendicular to CA, or that it cannot move in any other direction, then let it be required to find the most advantageous position of the plane CE, that it may receive the greatest impulse from the action of the fluid. Let AP be perpendicular to CE in P, draw AK parallel to CB, and let PK be perpendicular upon it in K; and AK will measure the force with which any particle of the fluid impels the plane EC in the direction CB. For the force of any such particle being represented by AC, let this force be resolved into AQ parallel to EC and AP perpendicular to it; and it is manifest, that the latter AP only has any effect upon the plane CE. Let this force AP be resolved into the force AL perpendicular to CB, and the force AK parallel to it; then it is manifest, that the former, AL, has no effect in promoting the motion of the plane in the direction CB; so that the latter, AK, only, measures the effort by which the particle promotes the motion of the plane CE, in the direction CB. Let EM and EN be perpendicular to CA and CB, in M and N; and the number of particles moving with directions parallel to AC, incident upon the plane CE, will be as EM. Therefore the effort of the fluid upon CE, being as the force of each particle, and the number of particles together, it will be as $AK \times EM$; or, because AK is to AP (= EM) as EN to CE, as $\frac{EM^2 EM \times EN}{CE}$; so that CE being given, the problem is reduced to this, to find when $EM^2 \times EN$ is the greatest possible, or a maximum. But because the sum of EM^2 and of EN^2 ($= CM^2$) is given, being always equal to CE^2, it follows that $EN^2 \times EM^4$ is greatest when $EN^2 = \frac{1}{3} CE^2$; for when the sum of two quantities AC and CB (fig 158.) was given, $AC \times BC^2$ is greatest when $AC = \frac{1}{3} AB$, as will be very evident if a semicircle is described upon AD. But when $EN^2 \times EM^2$ is greatest, its square root $EN \times EM^2$ is of necessity at the same time greatest. Therefore the action of the fluid upon the plane CE, in the direction CB, is greatest when $EN^2 = \frac{1}{3} CE^2$, and consequently $LM^2 = \frac{2}{3} CE^2$; that is, when EM, the sine of the angle ACE, in which the stream strikes the plane, is to the radius, as $\sqrt{2}$ to $\sqrt{3}$; in which case it easily appears from the trigonometrical tables, that this angle is of 54° 44′

Several useful problems in mechanics may be resolved by what we have just now shown. If we represent the velocity of the wind by AC, a section of the sail of a windmill perpendicular to its length by CE, as it follows from the nature of the engine, that its axis ought to be turned directly to the wind, and the sail can only move in a direction perpendicular to the axis, it appears, that, when the motion begins, the wind will have the greatest effect to produce this motion, when the angle ACE, in

which the wind strikes the sail, is of 54° 44′. In the same manner, if CB represent the direction of the motion of a ship, or the position of her keel, abstracting from her lee-way, and AC be the direction of the wind perpendicular to her way, then the most advantageous position of the sail CE, to promote her motion in the direction CB, is when the angle ACE, in which the wind strikes the sail, is of 54° 44′. The best position of the rudder, where it may have the greatest effect in turning round the ship, is determined in like manner.

Prob. V. To find the internal dimensions of a cylindrical cup, whose capacity is equal to a, when the cup is made with the least possible quantity of silver of a given thickness.

Put the diameter $= x$; and .7854 (the area of the circle whose diameter is 1) $= c$: then, by El. xii. 2, $cx^2 =$ the area of the bottom, and therefore $\frac{a}{cx^2} =$ the altitude; but $4cx =$ the circumference of the bottom, and therefore $4cx \times \frac{a}{cx^2} = \frac{4a}{x} =$ the inside curve superficies. Hence $cx^2 + \frac{4a}{x} =$ the whole inside superficies, which is a minimum; and therefore its fluxion is $= 0$: that is, $2cx\dot{x} - \frac{4a\dot{x}}{x^2} = 0$, or $2cx^3\dot{x} - 4a\dot{x} = 0$, or $cx^3 - 2a = 0$, therefore $cx^3 = 2a$, and $x = \sqrt[3]{\frac{2a}{c}} =$ diameter. By substituting this quantity for x in $\frac{a}{cx^2}$, we have $\frac{a}{c \times \overline{\frac{2a}{c}}|^{\frac{2}{3}}}$

$$= \frac{a \times \overline{\frac{2a}{c}}|^{\frac{1}{3}}}{c \times \frac{2a}{c}} = \frac{a}{c} \times \frac{\overline{\frac{2a}{c}}|^{\frac{1}{3}}}{\frac{2a}{c}} = \frac{ac}{2ac} \times \overline{\frac{2a}{c}}|^{\frac{1}{3}} = \tfrac{1}{2} \times \overline{\frac{2a}{c}}|^{\frac{1}{3}} =$$ altitude. Since then the diameter is $\overline{\frac{2a}{c}}|^{\frac{1}{3}}$ and the altitude is half that quantity, they will be to one another as 2 to 1, to answer the conditions of the problem.

Prob. VI. To find the greatest cone that can be inscribed in a given sphere.

Let AD (plate Miscel. fig. 159) the diameter of the sphere $= a$; 7854 (the area of a circle whose diameter is 1) $= c$; and AC, the altitude of the cone, $= x$; then CD $= a - x$. By El. iii. 35, AC $\times$ CD $=$ CB², that is, $x \times a - x = ax - x^2 =$ CB²; but the square of the diameter is four times the square of the radius; therefore, by El. xii. 2, $4acx - 4cx^2 =$ the area of the cone's base, which, by El. xii. 10, drawn into $\frac{1}{3}x$, is $\frac{4}{3}acx^2 - \frac{4}{3}cx^3 =$ the cone's solidity, which is a maximum; therefore, by taking away what is common, we get $ax^2 - x^3$ a maximum, the fluxion of which is $= 0$, that is, $2ax\dot{x} - 3x^2\dot{x} = 0$, or $2a = 3x$, and $x = \frac{2a}{3}$. So that the cone will be a maximum, when its altitude is equal to two-thirds of the sphere diameter.

MEAD, an agreeable liquor made of honey and water. See Honey.

There are many receipts for making mead, of which the following is one of the best. Take four gallons of water, and as much honey as will make it bear an egg; add to this the rind of three lemons, boil it, and scum it well as it rises. Then take it off the fire, and add the three lemons cut in pieces; pour it into a clean tub or open vessel, and let it work for three days; then scum it well, and pour off the clear part into a cask, and let it stand open till it ceases to make a hissing noise; then stop it up close, and in three months time it will be fine and fit for bottling. If you would give it a finer flavour, take cloves, mace, and nutmeg, of each four drams; beat them small, tie the powder in a piece of cloth, and put it into the cask.

MEADOW. See Husbandry.

MEAN, a middle state between two extremities; as a mean motion, mean distance, arithmetical mean, geometrical mean, &c.

Arithmetical Mean, is half the sum of the extremes. So, 4 is an arithmetical mean between 2 and 6, or between 3 and 5, or between 1 and 7; also an arithmetical mean between a and b is $\frac{a+b}{2}$, or $\frac{1}{2}a + \frac{1}{2}b$.

Geometrical Mean, commonly called a mean proportional, is the square root of the product of the two extremes; so that, to find a mean proportional between two given extremes, multiply these together, and extract the square root of the product. Thus, a mean proportional between 1 and 9, is $\sqrt{1 \times 9} = \sqrt{9} = 3$; a mean between 2 and $4\frac{1}{2}$ is $\sqrt{2 \times 4\frac{1}{2}} = \sqrt{9} = 3$ also; the mean between 4 and 6 is $\sqrt{4 \times 6} = \sqrt{24}$; and the mean between a and b is $\sqrt{ab}$.

The geometrical mean is always less than the arithmetical mean between the same two extremes. So the arithmetical mean between 2 and $4\frac{1}{2}$ is $3\frac{1}{4}$, but the geometrical mean is only 3. To prove this generally, let a and b be any two terms, a the greater, and b the less: then, universally, the arithmetical mean $\frac{a+b}{2}$ shall be greater than the geometrical mean $\sqrt{ab}$, or $a + b$ greater than $2\sqrt{ab}$. For, by

squaring both, they are $a^2 + 2ab + b^2 > 4ab$;
subtr. $4ab$ from each, then $a^2 - 2ab + b^2 > 0$,
that is, $(a - b)^2 > 0$.

To find a Mean Proportional geometrically, between two given lines M and N. Join the two given lines together at C, in one continued line AB; upon the diameter AB describe a semicircle, and erect the perpendicular CD; which will be the mean proportional between AC and CB, or M and N.

To find two Mean Proportionals between two given extremes. Multiply each extreme by the square of the other, viz. the greater extreme by the square of the less, and the less extreme by the square of the greater; then extract the cube root out of each product, and the two roots will be the two mean proportionals sought. That is, $\sqrt[3]{a^2b}$ and $\sqrt[3]{ab^2}$ are the two means between a and b. So, between 2 and 16, the two mean proportionals are 4 and 8; for $\sqrt[3]{2^2 \times 16} = \sqrt[3]{64} = 4$, and $\sqrt[3]{2 \times 16^2} = \sqrt[3]{512} = 8$.

In a similar manner we proceed for three means, or four means, or five means, &c.; from all which it appears,

that the series of the several numbers of mean proportionals between a and b will be as follows: viz.

1 mean, $\sqrt{ab}$;
2 means, $\sqrt[3]{a^2b}$. $\sqrt[3]{ab^2}$;
3 means, $\sqrt[4]{a^2b^2}$. $\sqrt[4]{a^2b}$, $\sqrt[4]{ab^3}$;
4 means, $\sqrt[5]{a^4b}$. $\sqrt[5]{a^2b^2}$, $\sqrt[5]{a^2b^3}$, $\sqrt[5]{ab^4}$;
5 means, $\sqrt[6]{a^5b}$, $\sqrt[6]{a^4b^2}$, $\sqrt[6]{a^3b^3}$, $\sqrt[6]{a^2b^4}$, $\sqrt[6]{ab^5}$:
&c. &c.

Harmonical MEAN, is double a fourth proportional to the sum of the extremes, and the two extremes themselves a and b: thus, as $a + b : a :: 2b : \frac{2ab}{a+b} = m$, the harmonical mean between a and b. Or it is the reciprocal of the arithmetical mean between the reciprocals of the given extremes; that is, take the reciprocals of the extremes a and b, which will be $\frac{1}{a}$ and $\frac{1}{b}$; then take the arithmetical mean between these reciprocals, or half their sum, which will be $\frac{1}{2a} + \frac{1}{2b}$, or $\frac{a+b}{2ab}$; lastly, the reciprocal of this is $\frac{2ab}{a+b} = m$, the harmonical mean: for arithmeticals and harmonicals are mutually reciprocals of each other;

so that if a, m, b, &c. be arithmeticals,

then shall $\frac{1}{a}$, $\frac{1}{m}$, $\frac{1}{b}$, &c. be harmonicals; or if the former be harmonicals, the latter will be arithmeticals.

For example, to find a harmonical mean between 2 and 6: here $a = 2$, and $b = 6$; therefore $\frac{2ab}{a+b} = \frac{2 \times 2 \times 6}{2 + 6} = \frac{24}{8} = 3 = m$, the harmonical mean sought between 2 and 6.

Pappus has shown a curious similiarity that subsists between the three different sorts of mean: a, m, b, being three continued terms, either arithmeticals, geometricals, or harmonicals, then in the

Arithmeticals $a : a :: a - m : m - b$
Geometricals $a : m :: a - m : m - b$
Harmonicals $a : b :: a - m : m - b$.

MEASLES. See MEDICINE.

MEASURE *of an angle*, is an arch described from the vertex in any place between its legs. Hence angles are distinguished by the ratio of the arches, described from the vertex between the legs to the peripheries. Angles then are distinguished by those arches; and the arches are distinguished by their ratio to the periphery: thus an angle is said to be so many degrees as there are in the said arch. See ANGLE.

MEASURE *of a figure*, or plane surface, is a square whose side is one inch, one foot, one yard, or some other determined length. Among geometricians, it is usually a rod called a square rod, divided into 10 square feet, and the square feet into 10 square digits.

MEASURE *of a solid*, is a cube whose side is one inch, foot, yard, or any other determinate length. In geometry it is a cubic perch, divided into cubic feet, digits, &c. Hence cubic measures, or measures of capacity. See SPHERE, CUBE, &c.

MEASURE *of velocity*, in mechanics, the space passed over by a moving body in a given time. To measure a velocity therefore, the space must be divided into as many equal parts as the time is conceived to be divided into; the quantity of space answering to such a part of time is the measure of the velocity.

MEASURE, in geometry, denotes any quantity assumed as one, or unity, to which the ratio of the other homogenous or similar quantities is expressed.

Measures in a legal and commercial sense are various, according to the various kinds and dimensions of the things measured. Hence arise lineal or longitudinal measures, for lines or lengths, square measures, for areas or superficies; and solid or cubic measures, for bodies and their capacities; all which again are very different in different countries and in different ages, and even many of them for different commodities. Whence arise other divisions of ancient and modern measures, domestic and foreign ones, dry measures, liquid measures, &c.

I. *Long measures, or measures of application.*

1. The English and Scotch standards.

The English lineal standard is the yard, containing 3 English feet, equal to 3 Paris feet 1 inch and $\frac{3}{12}$ of an inch, or $\frac{7}{9}$ of a Paris ell. The use of this measure was established by Henry I. of England, and the standard taken from the length of his own arm. It is divided into 36 inches, and each inch is supposed equal to 3 barleycorns. When used for measuring cloth, it is divided into 4 quarters, and each quarter subdivided into 4 nails. The English ell is equal to a yard and a quarter, or 45 inches, and is used in measuring linens imported from Germany and the Low-countries.

The Scots elwand was established by king David I. and divided into 37 inches. The standard is kept in the council-chamber of Edinburgh, and being compared with the English yard, is found to measure $37\frac{1}{5}$ inches; and therefore the Scots inch and foot are larger than the English, in the proportion of 180 to 185; but this difference being so inconsiderable, is seldom attended to in practice. The Scots ell, though forbidden by law, is still used for measuring some coarse commodities, and is the foundation of the land-measure of Scotland.

Itinerary measure is the same both in England and Scotland. The length of the chain is 4 poles, or 22 yards; 80 chains make a mile. The old Scots computed miles were generally about a mile and a half each.

The reel for yarn is $2\frac{1}{2}$ yards, or 10 quarters, in circuit; 120 threads make a cut; 12 cuts make a hasp or hank, and 4 hanks make a spindle.

2. The French standard was formerly the aune or ell, containing 3 Paris feet, 7 inches, 8 lines, or 1 yard $\frac{2}{7}$ English; the Paris foot royal exceeding the English by $\frac{68}{1000}$ parts, as in one of the following tables. This ell is divided two ways, viz. into halves, thirds, sixths, and twelfths; and into quarters, half-quarters, and sixteenths.

The French, however, have also formed an entirely new system of weights and measures, according to the following table:

Proportion of the measures of each species to its principal measure or unity.	First part of the name which indicates the proportion to the principal measure or unity.	PRINCIPAL MEASURES OR UNITIES.				
		Length.	Capacity.	Weight.	Agrarian.	For firewood.
10,000 1,000 100 10 1 0.1 0.01 0.001	Myria Kilo Hecto Deca —— Deci Centi Milli	Metre.	Litre.	Gramme.	Are.	Stere.
Proportion of the principal measures between themselves, and the length of the meridian.		10,000,000 part of the dist. from the pole to the equator.	A decimetre cube.	Weight of a centimetre cube of distilled water.	100 square metres.	One cubic metre.
Value of the principal measures in the ancient French measures.		3 feet 11 lines and $\frac{1}{2}$ nearly.	1 pint and $\frac{1}{20}$, or 1 liton and $\frac{1}{4}$ nearly.	18 grains and 841,000 parts.	Two square perches des eaux et foret.	1 demi-voie, or $\frac{1}{4}$ of a cord des eaux et foret.
Value in English measures.		Inches 39,383	61.083 inches, which is more than the wine and less than the beer quart.	22.966 grains.	11.968 square yards.	

3. The English avoirdupois pound weighs 7004 troy grains; whence the avoirdupois ounce, whereof 16 make a pound, is found equal to 437.75 troy grains. And it follows, that the troy pound is to the avoirdupois pound as 88 to 107 nearly; for as 88 to 107, so is 5760 to 7003.636: that the troy ounce is to the avoirdupois ounce, as 80 to 73 nearly; for as 80 to 73, so is 480 to 438: and, lastly, that the avoirdupois pound and ounce are to the Paris two-marc weight and ounce, as 63 to 68 nearly; for as 63 to 68, so is 7004 to 7559.873. See Weight. 4. The Paris foot expressed in decimals is equal to 1.0654 of the English foot, or contains 12.785 English inches.

3. The standard in Holland, Flanders, Sweden, a good part of Germany, many of the Hanse-towns, as Dantzic and Hamburgh, and at Geneva, Franckfort, &c. is likewise the ell; but the ell in all these places differs from the Paris ell. In Holland it contains one Paris foot 11 lines, or 4-sevenths of the Paris ell. The Flanders ell contains 2 feet 1 inch 5 lines and half a line, or 7-twelfths of the Paris ell. The ell of Germany, Brabant, &c. is equal to that of Flanders.

4. The Italian measure is the bracchio, brace, or fathom. This obtains in the states of Modena, Venice, Florence, Lucca, Milan, Mantua, Bologna, &c. but is of different lengths. At venice it contains 1 Paris foot, 11 inches, 3 lines, or 8-fifteenths of the Paris ell. At Bologna, Modena, and Mantua, the brace is the same as at Venice. At Lucca it contains 1 Paris foot, 9 inches, 10 lines, or half a Paris ell. At Florence it contains 1 foot, 9 inches, four lines, or 49-hundredths of a Paris ell. At Milan, the brace for measuring of silks is 1 Paris foot, 7 inches, 4 lines, or 4 ninths of a Paris ell; that for woollen cloths is the same with the ell of Holland. Lastly, at Bergama, the brace is 1 foot 7 inches, 6 lines, or 5 ninths of a Paris ell. The usual measure at Naples, however, is the anna, containing 6 feet, 10 inches, and 2 nes, or one Paris ell and 15-seventeenths.

5. The Spanish measure is the vara or yard, in some places called the barra; containing 17 twenty-fourths of the Paris ell. But the measure in Castile and Valencia is the pan, span, or palm; which is used, together with the canna, at Genoa. In Arragon, the vara, is equal to a Paris ell and a half, or 5 feet, 5 inches, 6 lines.

6. The Portuguese measure is the cavedos, containing 2 feet, 11 lines, or four-sevenths of a Paris ell; and the vara, 106 whereof make a 100 Paris ell.

7. The Piedmontese measure is the ras, containing 1 Paris foot, 9 inches, 10 lines, or half a Paris ell. In Sicily, their measure is the canna, the same with that of Naples.

8. The Muscovite measures are the cubit, equal to 1 Paris foot, 4 inches, 2 lines; and the arcin, two whereof are equal to 3 cubits.

9. The Turkish and Levant measures are the picq, containing 2 feet, 2 inches, and 2 lines, or three-fifths of the Paris ell. The Chinese measure is the cobre, ten whereof are equal to three Paris ells. In Persia, and some parts of the Indies, the gueze, of which there are two kinds; the royal gueze, called also the gueze monkelser, containing 2 Paris feet, 10 inches, 11 lines, or four-fifths of the Paris ell; and the shorter gueze, called simply gueze, only two-thirds of the former. At Goa and Ormuz, the measure is the vara, the same with that of the Portuguese, having been introduced by them. In Pegu, and some other parts of the Indies, the cando or candi, equal to the ell of Venice. At Goa, and other parts, they

use a larger cando, equal to 17 Dutch ells, exceeding that of Babel and Balsora by $\frac{7}{8}$ per centum, and the vara by $6\frac{1}{2}$. In Siam, they use the ken, short of three Paris feet by one inch. The ken contains two soks, the sok two keubs, the keub 12 nious or inches, the niou to be equal to eight grains of rice, *i. e.* to about nine lines. At Camboia they use the haster; in Japan the tatam; and the span on some of the coasts of Guinea.

English MEASURES of Length.

Barley-corns											
3	Inch										
9	3	Palm									
27	9	3	Span								
36	12	4	$1\frac{1}{3}$	Foot							
54	18	6	2	$1\frac{1}{2}$	Cubit						
108	36	12	4	3	2	Yard					
180	60	20	$6\frac{2}{3}$	5	$3\frac{1}{3}$	$1\frac{2}{3}$	Pace				
216	72	24	8	6	4	2	$1\frac{1}{5}$	Fathom			
594	198	66	22	$16\frac{1}{2}$	11	$5\frac{1}{2}$	$3\frac{3}{10}$	$2\frac{3}{4}$	Pole		
23760	7920	2640	880	660	440	220	132	110	40	Furlong	
190080	63360	21120	7040	5280	3520	1760	1056	880	320	8	Mile.

Scripture MEASURES of Length, reduced to English.

								Eng. feet.	Inch. Dec.
Digit								0	0.912
4	Palm							0	3.643
12	3	Span						0	10.944
24	6	2	Cubit					1	9.888
96	24	8	4	Fathom				7	3.552
144	36	12	6	$1\frac{1}{2}$	Ezekiel's reed			10	11.328
192	48	16.	8	2	$1\frac{1}{3}$	Arabian pole		14	7.104
1920	480	160	80	20	$13\frac{1}{2}$	10	Schœnus, or measuring line	145	11.04

The Longer Scripture MEASURES.

						English miles.	paces.	feet.
Cubit						0	0	1.824
400	Stadium					0	145	4.6
2000	5	Sab. day's journey				0	729	3.000
4000	10	2	Eastern mile			1	403	1.000
12000	30	6	3	Parasang		4	153	3.000
96000	240	48	24	8	A day's journey	33	172	4.000

Grecian Measures of Length, reduced to English.

												English paces.	feet.	dec.
Dactylus, digit												0	0	$0.7554\frac{1}{16}$
4	Doran, dochme											0	0	$3.0218\frac{3}{4}$
10	$2\frac{1}{2}$	Lichas										0	0	$7.5546\frac{7}{8}$
11	$2\frac{3}{4}$	$1\frac{1}{10}$	Orthodoron									0	0	$8.3101\frac{9}{16}$
12	3	$1\frac{1}{5}$	$1\frac{1}{11}$	Spithame								0	0	$9.0656\frac{1}{4}$
16	4	$1\frac{6}{10}$	$1\frac{5}{11}$	$1\frac{1}{3}$	Foot							0	1	0.0875
18	$4\frac{1}{2}$	$1\frac{4}{5}$	$1\frac{7}{11}$	$1\frac{1}{2}$	$1\frac{1}{8}$	Cubit						0	1	$1.5984\frac{3}{8}$
20	5	2	$1\frac{9}{11}$	$1\frac{2}{3}$	$1\frac{1}{4}$	$1\frac{1}{9}$	Pygon					0	1	$3.109\frac{3}{8}$
24	6	$2\frac{2}{5}$	$2\frac{2}{11}$	2	$1\frac{1}{2}$	$1\frac{1}{3}$	$1\frac{1}{5}$	Cubit larger				0	1	6.13125
96	24	$9\frac{3}{5}$	$8\frac{8}{11}$	8	6	$5\frac{1}{3}$	$4\frac{4}{5}$	4	Pace			0	6	0.525
9600	2400	960	$872\frac{8}{11}$	800	600	$533\frac{1}{3}$	480	400	100	Furlong		100	4	4.5
76800	19200	7680	$6981\frac{9}{11}$	6400	4800	$4266\frac{2}{3}$	3840	3200	800	8	Mile	805	5	0

Roman Measures of Length, reduced to English.

										English Paces.	feet.	dec.
Digitus transversus										0	0	$0.725\frac{1}{4}$
$1\frac{1}{3}$	Uncia									0	0	0.967
4	3	Palmus minor								0	0	2.901
16	12	4	Pes							0	0	11.604
20	15	5	$1\frac{1}{4}$	Palmipes						0	1	2.505
24	18	6	$1\frac{1}{2}$	$1\frac{1}{5}$	Cubitus					0	1	5.406
40	30	10	$2\frac{1}{2}$	2	$1\frac{2}{3}$	Gradus				0	2	5.01
80	60	20	5	4	$3\frac{1}{3}$	2	Passus			0	4	10.02
10000	7500	2500	625	500	$416\frac{2}{3}$	250	125	Stadium		120	4	4.5
80000	60000	20000	5000	4000	$3333\frac{1}{3}$	2000	1000	8	Milliare	967	0	0

A TABLE

Of the Measures of Length of the principal Places in Europe, compared with the English Yard.

			Eng. yard.
100	Aunes,	or ells of England, equal to	125
100		of Holland or Amsterdam	75
100		of Brabant or Antwerp	76
100		of France	$128\frac{1}{4}$
100		of Hamburgh, Francfort, &c.	$62\frac{1}{2}$
100		of Breslau	60
100		of Dantzick	$66\frac{3}{4}$
100		of Bergen and Drontheim	$68\frac{1}{4}$
100		of Sweden or Stockholm	$65\frac{3}{4}$
100		of St. Gall, for linens	$87\frac{1}{2}$
100		of ditto, cloths	67
100		of Geneva	$124\frac{3}{4}$
100	Canes	of Marseilles and Montpelier	$214\frac{1}{2}$
100		of Toulouse & High Languedoc	200
100		of Genoa, of 9 palms	$245\frac{1}{4}$
100		of Rome	$227\frac{1}{4}$
100	Varas	of Spain	$93\frac{3}{4}$
100		of Portugal	123
100	Cavidos	of Portugal	75
102	Brasses	of Venice	$73\frac{1}{2}$
100		of Bergamo, &c.	$71\frac{1}{4}$
100		of Florence and Leghorn	64
100		of Milan	$58\frac{1}{2}$

N. B. The aunes or ells of Amsterdam, Haerlem, Leyden, the Hague, Rotterdam, and other cities of Holland, as also that of Nuremberg, being all equal, are comprehended under that of Amsterdam; as those of Osnaburg are under those of France; and those of Bern and Basil are equal to those of Hamburg, Francfort, and Leipsic.

For the subdivisions and multiples of each of these measures of length, see the article AUNE.

For the proportion of the feet of the principal nations in Europe, compared with the English foot, see the article FOOT.

Square, or *Superficial* MEASURES. English square or superficial measures are raised from the yard of 36 inches multiplied into itself, and thus producing 1296 square inches in the square yard: the divisions of this are square feet and inches; and the multiples, poles, roods, and acres, as in the following table:

English SQUARE MEASURES.

Inches						
144	Foot					
1296	9	Yard				
3600	25	$2\frac{7}{9}$	Pace			
39204	$272\frac{1}{4}$	$30\frac{1}{4}$	10.89	Pole		
1568160	10890	1210	435.6	40	Rood	
6272640	43560	4840	1743.6	160	4	Acre.

Roman SQUARE-MEASURE reduced to English.

The integer was the jugerum or acre, which the Romans divided like the libra or as: thus, the jugerum contained

	Square feet.	Scruples.	English roods.	Square poles.	Square feet.
As	28800	288	2	18	[illegible]0.05
Deunx	26400	264	2	10	183.85
Dextans	24000	240	2	2	117.64
Dodrans	21600	216	1	34	51.42
Bes	19200	192	1	25	257.46
Septunx	16800	168	1	17	191.25
Semis	14400	144	1	9	125.03
Quincunx	12000	120	1	1	58.82
Triens	9600	96	0	32	264.85
Quadrans	7200	72	0	24	198.64
Sextans	4800	48	0	16	132.43
Uncia	2400	24	0	8	66.21

Note. Actus major was 14400 square feet, equal to a semis; clima, 3600 square feet, equal to a sescuncia; and actus minimus equal to a sextans.

Cubical MEASURES, *or Measures of capacity for liquids.* The English measures were originally raised from troy-weight: it being enacted by several statutes that eight pounds troy of wheat gathered from the middle of the ear, and well dried, should weigh a gallon of wine-measure, the divisions and multiples whereof were to form the other measures; at the same time it was also ordered, that there should be but one liquid measure in the kingdom: yet custom has prevailed, and there having been introduced a new weight, viz. the avoirdupois, we have now a second standard gallon adjusted thereto, and therefore exceeding the former in the proportion of the avoirdupois weight to troy weight. From this latter standard are raised two several measures, the one for ale, the other for beer.

The sealed gallon at Guildhall, which is the standard for wines, spirits, oils, &c. is supposed to contain 231 cubic inches; and on this supposition the other measures raised therefrom, will contain as in the table underneath; yet, by actual experiment, made in 1688, before the lord-mayor and the commissioners of excise, this gallon was found to contain only 224 cubic inches: it was however agreed to continue the common supposed contents of 231 cubic inches; so that all computations stand on their old footing. Hence, as 12 is to 231, so is $14\frac{1}{2}\frac{2}{0}$ to $281\frac{1}{2}$ the cubic inches in the ale gallon: but in effect the ale quart contains $70\frac{1}{2}$ cubic inches, on which principle the ale and beer gallon will be 282 cubic inches. The several divisions and multiples of these measures, and their proportions, are exhibited in the following tables:

English MEASURE of Capacity for Liquids.

Wine-Measure.

Solid inches									
$28\frac{7}{8}$	Pint								
231	8	Gallon							
4158	144	18	Runlet						
$7276\frac{1}{2}$	252	$31\frac{1}{2}$	$1\frac{3}{4}$	Barrel					
9702	336	42	$2\frac{1}{3}$	$1\frac{1}{3}$	Tierce				
14553	504	63	$3\frac{1}{2}$	2	$1\frac{1}{2}$	Hogshead			
19279	672	84	$4\frac{2}{3}$	$2\frac{2}{3}$	2	$1\frac{1}{3}$	Puncheon		
29106	1008	126	7	4	3	2	$1\frac{1}{2}$	Butt	
58212	2016	252	14	8	6	4	3	2	Tun.

Jewish MEASURES of Capacity for Liquids, reduced to English Wine Measure.

							Gall.	Pint.	Solid inch.
Caph							0	$0\frac{5}{8}$	0.177
$1\frac{1}{3}$	Log						0	$0\frac{5}{6}$	0.211
$5\frac{1}{3}$	4	Cab					0	$3\frac{1}{3}$	0.844
16	12	3	Hin				1	2	2.533
32	24	6	2	Seah			2	4	5.067
96	72	18	6	3	Bath, or Epha		7	4	15.2
960	720	180	60	30	10	Coron, or Chomer	75	5	7.625

Attic MEASURES of Capacity for Liquids, reduced to English Wine measure.

										Gall.	Pint.	Solid inch. Dec.
Cochliarion										0	$\frac{1}{120}$	0.0356 $\frac{5}{12}$
2	Cheme									0	$\frac{1}{60}$	0.0712 $\frac{5}{6}$
$2\frac{1}{2}$	$1\frac{1}{4}$	Mystron								0	$\frac{1}{48}$	0.089 $\frac{11}{48}$
5	$2\frac{1}{2}$	2	Conche							0	$\frac{1}{24}$	0.178 $\frac{11}{24}$
10	5	4	2	Cyathos						0	$\frac{1}{12}$	0.356 $\frac{11}{12}$
15	$7\frac{1}{2}$	6	3	$1\frac{1}{2}$	Oxybaphon					0	$\frac{1}{8}$	0.535 $\frac{3}{8}$
60	30	24	12	6	4	Cotyle				0	$\frac{1}{2}$	2.141 $\frac{1}{2}$
120	60	48	24	12	8	2	Xestes			0	1	4.283
720	360	288	144	72	48	12	6	Chous		0	6	25.698
8640	4320	3416	1728	864	576	144	72	12	Metretes	10	2	19.629

Roman MEASURES of Capacity for Liquids, reduced to English Wine measure.

										Gal.	Pint.	Solid inch. Dec.
Ligula										0	0 $\frac{1}{48}$	0.117 $\frac{5}{12}$
4	Cyathus									0	0 $\frac{1}{12}$	0.469 $\frac{2}{3}$
6	$1\frac{1}{2}$	Acetabulum								0	0 $\frac{1}{8}$	0.704 $\frac{1}{2}$
12	3	2	Quartarius							0	0 $\frac{1}{4}$	1.409
24	6	4	2	Hemina						0	0 $\frac{1}{2}$	2.818
48	12	8	4	2	Sextarius					0	1	5.636
288	72	48	24	12	6	Congius				0	7	4.942
1152	288	192	96	48	24	4	Urna			3	4 $\frac{1}{2}$	5.33
2304	576	384	192	96	48	8	2	Amphora		7	1	10.66
46080	11520	7680	3840	1920	960	160	40	20	Culeus	143	3	11.095

Beer and Ale Measure.

Pints					
8	Gallon				
72	9	Firkin			
144	18	2	Kilderkin		
288	36	4	2	Barrel	
576	72	8	4	2	Hogshead.

English Dry or Corn Measure.

Solid inches					
33.6	Pint				
268.8	8	Gallon			
537.6	16	2	Peck		
2150.4	64	8	4	Bushel	
17203.2	512	64	32	8	Quarter.

Scripture Measures of Capacity for things dry, reduced to English Corn measure.

							Peck.	Gall.	Pint.	Solid inch. Dec.
Gachal							0	0	$0\frac{17}{120}$	0.031
20	Cab						0	0	$2\frac{5}{6}$	0.078
36	$1\frac{4}{5}$	Gomor					0	0	$5\frac{1}{10}$	1.211
120	6	$3\frac{1}{3}$	Seah				1	0	1	4.036
360	18	10	3	Epha			3	0	3	12.107
1800	90	50	15	5	Leteeh		16	0	0	26.500
3600	180	100	30	10	2	Chomer, or Coron	32	0	1	18.969

Attic Measures of Capacity for things dry, reduced to English Corn measure.

							Peck.	Gall.	Pint.	Solid inch. Dec.
Cochliarion							0	0	0	$0.276\frac{7}{20}$
10	Cyathos						0	0	0	$2.763\frac{1}{2}$
15	$1\frac{1}{2}$	Oxybaphon					0	0	0	$4.144\frac{3}{4}$
60	6	4	Cotyle				0	0	0	16.579
120	12	8	2	Xestes			0	0	0	33.158
180	18	12	3	$1\frac{1}{2}$	Choenix		0	0	1	$15.705\frac{3}{4}$
8640	864	576	144	72	48	Medimnos	4	0	6	3.501

Roman Measures of Capacity for things dry, reduced to English Corn measure.

							Peck.	Gal.	Pint.	Solid inch. Dec.
Ligula							0	0	$0\frac{1}{48}$	0.01
4	Cyathus						0	0	$0\frac{1}{24}$	0.04
6	$1\frac{1}{2}$	Acetabulum					0	0	$0\frac{1}{8}$	0.06
24	6	4	Hemina				0	0	$0\frac{1}{2}$	0.24
48	12	8	2	Sextarius			0	0	1	0.48
384	96	64	16	8	Semimodius		0	1	0	3.84
768	192	128	32	16	2	Modius	1	0	0	7.68

Measure *for horses*, is the hand, which by statute contains four inches.

MEATUS AUDITORIUS. See Anatomy.

MECHANICS, that branch of practical mathematics which considers motion and moving powers, their nature and laws, with their effects in machines.

The term mechanics is equally applied to the doctrine of the equilibrium of powers, more properly called statics; and to that science which treats of the generation and communication of motion, which constitutes mechanics strictly so called. See Statics, Power, Motion, &c.

The knowledge of mechanics is one of those things, says Mr. Mac Laurin, that serve to distinguish civilized nations from barbarians. It is by this science that the utmost improvement is made of every power and force in nature; and the motions of the elements, water, air, and fire, are made subservient to the various purposes of life; for however weak the force of man appears to be, when unassisted by this art; yet, with its aid, there is hardly any thing above his reach. It is distinguished by sir Isaac Newton into practical and rational mechanics; the former of which treats of the mechanical powers, viz. the lever, balance, axis and wheel, pulley, wedge, screw, and inclined plane.

Rational mechanics comprehends the whole theory of motion, shows when the powers or forces are given how to determine the motions that are produced by them; and conversely when the phænomena of the motions are given, how to trace the powers or forces from which they arise.

Mechanical powers are simple engines that enable men to raise weights, to move heavy bodies, and overcome resistances, which they could not do with their natural strength alone. Their importance to society is incalculable. Every machine whatever is composed of one or more of them, sometimes of several combined together.

In considering this science, it will be necessary at first to take some things for granted that are not strictly true; and after the theory is established, to make the proper allowances for them.

1. That a small portion of the earth's surface, which is spherical, may be considered as a plane. 2. That all bodies be supposed to descend in lines parallel to each other; for though all bodies really tend to the centre of the earth, yet the distance from which they fall, is comparatively so small, that their inclination towards each other is inconsiderable. 3. That all planes be considered as perfectly smooth; levers to be inflexible, and without thickness or weight; cords perfectly pliable; and machines without friction and inertia.

Three things are always to be considered in treating of mechanical engines; the weight to be raised, the power by which it is to be raised, and the instrument or engine by which this is to be effected.

The mechanical powers are generally reckoned six; the lever, the pulley, the wheel and axis, the inclined plane, the wedge, and the screw.

These perhaps may be reduced to two; for the pulley and wheel are only assemblages of levers, and the wedge and screw are inclined planes.

To calculate the power of a machine, it is usually considered in a state of equilibrium; that is, in the state when the power which is to overcome the resistance just balances it. Having discovered what quantity of power will be requisite for this purpose, it will then be necessary to add so much more as to overcome the friction and weight of the machine itself, and to give the necessary velocity.

The *lever* is the simplest of all machines; and is only a straight bar of iron, wood, or other material, supported on, and moveable round, a prop called the fulcrum.

In the lever there are three circumstances to be principally attended to: 1. The fulcrum, or prop, by which it is supported, or on which it turns as an axis, or centre of motion: 2. The power to raise and support the weight: 3. The resistance or weight to be raised or sustained.

The points of suspension are those points where the weights really are, or from which they hang freely. The power and the weight are always supposed to act at right angles to the lever, except it is otherwise expressed.

The lever is distinguished into three sorts, according to the different situations of the fulcrum or prop, and the power, with respect to each other. 1. When the prop is placed between the power and the weight. 2. When the prop is at one end of the lever, the power at the other, and the weight between them. 3. When the prop is at one end, the weight at the other, and the power applied between them.

A poker, in stiring the fire, is a lever of the first sort: the bar of the grate upon which it rests is the fulcrum the fuel, the weight to be overcome; and the hand is the power. The lever of the first kind is principally used for loosening large stones; or to raise great weights to small heights, in order to get ropes under them, or other means of raising them to still greater heights; it is the most common species of lever.

ABC, Plate LXXXIII. Mechanics, fig. 1. is this lever, in which B is the fulcrum, A the end at which the power is applied, and C the end where the weight acts.

To find when an equilibrium will take place between the power and the weight, in this as well as in every other species of lever, it is necessary to recollect, that when the momenta, or quantities of force, in two bodies are equal, they will balance each other. Now let us consider when this will take place in the lever. Suppose the lever AB (fig. 2) to be turned on its axis, or fulcrum, so as to come into the situation DC; as the end D is farthest from the centre of motion, and as it has moved through the arch AD in the same time as the end B moved through the arch BC, it is evident that the velocity of AB must have been greater than that of B. But the momenta being the products of the quantities of matter multiplied into the velocities, the greater the velocity, the less the quantity of matter need be to get the same product. Therefore, as the velocity of A is the greatest, it will require less matter to produce an equilibrium than B.

Let us next see how much more weight B will require than A to balance it. As the radii of circles are in proportion to their circumferences, they are also proportionate to similar parts of them; therefore, as the arches AD, CB, are similar, the radius or arm DE bears the same proportion to EC that the arch AD bears to CB. But the arches AD and CB represent the velocities of the ends of the lever, because they are the spaces which they moved over in the same time; therefore the arms DE and EC may also represent these velocities.

It is evident then, that an equilibrium will take place when the length of the arm AE multiplied into the power A, shall equal EB multiplied into the weight B; and consequently, that the shorter EB is, the greater must be the weight B; that is, the power and the weight must be to each other inversely, as their distances from the fulcrum. Thus, suppose AE, the distance of the power from the prop, to be 20 inches, and EB, the distance of the weight from the prop, to be eight inches, also the weight to be raised at B to be five pounds, then the power to be applied at A must be two pounds; because the distance of the weight from the fulcrum eight, multiplied into the weight five, makes 40; therefore 20, the distance of the power from the prop, must be multiplied by two, to get an equal product, which will produce an equilibrium.

It is obvious, that while the distance of the power from the prop exceeds that of the weight from the prop, a power less than the weight will raise it, so that then the lever affords a mechanical advantage: when the distance of the power is less than that of the weight from the prop, the power must be greater than the weight to raise it; when both the arms are equal, the power and the weight must be equal, to be in equilibrio.

The second kind of lever, when the weight is between the fulcrum and the power, is represented by fig. 3. in which A is the fulcrum, B the weight, and C the power. The advantage gained by this lever, as in the first, is as great as the distance of the power from the prop exceeds the distance of the weight from it. Thus if the point *a*, on which the power acts, is seven times as far from A as the point *b*, on which the weight acts, then one pound applied at C will raise seven pounds at B.

This lever shows the reason why two men carrying a burden upon a stick between them, bear shares of the burden which are to one another in the inverse proportion of their distances from it. For it is well known, that the nearer either of them is to the burden, the greater share he bears of it; and if he goes directly under it, he bears the whole. So if one man is at A, and the other at *a*, having the pole or stick resting on their shoulders; if the burden or weight B is placed five times as near the man at A, as it is to the man at *a*, the former will bear five times as much weight at the latter.

This is likewise applicable to the case of two horses of unequal strength to be so yoked, that each horse may draw a part proportional to his strength; which is done by so dividing the beam they pull, that the point of traction may be as much nearer to the stronger horse than to the weaker, as the strength of the former exceeds that of the latter.

To this kind of lever may be reduced oars, rudders of ships, doors turning upon hinges, cutting-knives which are fixed at the point, &c.

If in this lever we suppose the power and weight to change places, so that the power may be between the weight and the prop, it will become a lever of the third kind; in which, that there may be a balance between the power and the weight, the intensity of the power must exceed the intensity of the weight just as much as the distance of the weight from the prop exceeds the distance of the power. Thus, let E (fig. 4.) be the prop of the lever EF, and W a weight of one pound, placed three times as far from the prop as the power P acts at F, by the cord going over the pulley D: in this case the power must be equal to three pounds, in order to support the weight of one pound.

To this sort of lever are generally referred the bones of a man's arm; for when he lifts a weight by the hand, the muscle that exerts its force to raise that weight is fixed to the bone about one-tenth part as far below the elbow as the hand is. And the elbow being the centre round which the lower part of the arm turns, the muscle must therefore exert a force ten times as great as the weight that is raised.

As this kind of lever is a disadvantage to the moving power, it is used as little as possible; but in some cases it cannot be avoided, such as that of a ladder, which being fixed at one end, is by the strength of a man's arms reared against a wall.

What is called the hammer-lever differs in nothing but its form, from a lever of the first kind. Its name is derived from its use, that of drawing a nail out of wood by a hammer.

Suppose the shaft of a hammer to be five times as long as the iron part which draws the nail, the lower part resting on the board as a fulcrum; then by pulling backwards the end of the shaft, a man will draw a nail with one-fifth part of the power that he must use to pull it out with a pair of pincers, in which case the nail would move as fast as his hand; but with the hammer the hand moves five times as much as the nail, by the time that the nail is drawn out.

Let ACB (fig. 5.) represent a lever of this sort, bent at C, which is its prop, or centre of motion. P is a power acting upon the longer arm AC, at A, by the means of the cord DA going over the pulley D; and W is a weight or resistance acting upon the end B of the shorter arm CB. If the power is to the weight as CB is to CA, they are in equilibrio: thus, suppose W to be five pounds, acting at the distance of one foot from the centre of motion C, and P to be one pound, acting at A, five feet from the centre C; the power and weight will just balance each other.

Thus we see, that in every species of lever there will be an equilibrium, when the power is to the weight, as the distance of the weight from the fulcrum is to the distance of the power from the fulcrum.

In making experiments on the mechanic powers, some difficulties arise from the weight of the materials; but as it is impossible to find any that are without weight, we take care that they are perfectly balanced themselves, before the weights and powers are applied. The bar, therefore, used in making experiments on levers, has the short end so much thicker than the long arm, as will be sufficient to balance it on the prop.

Hitherto we have supposed that the power and weight acted perpendicularly upon the lever; but they do not, they act with less force upon it; the power should, therefore, if possible, be always made to act at right angles to the lever.

If several levers are combined together in such a manner, as that a weight being appended to the first lever, may be supported by a power applied to the last, as in fig. 6. (which consists of three levers of the first kind, and is so contrived, that a power applied at the point L of the lever C, may sustain a weight at the point S of lever A), the power must here be to the weight, in ratio, or proportion, compounded of the several ratios, which those powers that can sustain the weight by the help of each lever, when used singly and apart from the rest, have to the weight. For instance: if the power which can sustain the weight P by the help of the lever A, is to the weight as 1 to 5; and if the power which can sustain the same weight by the lever B alone, is to the weight as 1 to 4; and if the power which could sustain the same weight by the lever C, is to the weight as 1 to 5; then the power which will sustain the weight by the help of the three levers joined together, will be to the weight in a proportion consisting of the several proportions multiplied together, of 1 to 5, 1 to 4, and 1 to 5; that is, of 1 to 100.

For since, in the lever A, a power equal to one-fifth of the weight P pressing down the lever at L, is sufficient to balance the weight; and since it is the same thing whether that power is applied to the lever A at L, or the lever B at S, the point S bearing on the point L; a power equal to one-fifth of the weight P, being applied to the point S of the lever B, will support the weight; but one-fourth of the same power being applied to the

point L of the lever B, and pushing the same upward, will as effectually depress the point S of the same lever, as if the whole power was applied at S; consequently a power equal to one-fourth of one-fifth, that is, one-twentieth of the weight P, being applied to the point L of the lever B, and pushing up the same, will support the weight; in like manner, it matters not whether that force is applied to the point L of the lever B, or to the point S of the lever C, since, if S be raised, L, which rests on it, must be raised also; but one-fifth of the power applied at the point L of the lever C, and pressing it downwards, will as effectually raise the point S of the same lever, as if the whole power was applied at S, and pushed up the same; consequently a power equal to one-fifth of one-twentieth, that is, one-hundredth part of the weight P, being applied to the point L of the lever C, will balance the weight at the point S of the lever A.

The balance, an instrument of very extensive use in comparing the weights of bodies, is a lever of the first kind, whose arms are of equal length. The points from which the weights are suspended being equally distant from the centre of motion, will move with equal velocity; consequently, if equal weights are applied, their momenta will be equal, and the balance will remain in equilibrio.

In order to have a balance as perfect as possible, it is necessary to attend to the following circumstances:

1. The arms of the beam ought to be exactly equal, both as to weight and length.

2. The points from which the scales are suspended should be in a right line, passing through the centre of gravity of the beam: for by this the weights will act directly against each other, and no part of either will be lost on account of any oblique direction.

3. If the fulcrum, or point upon which the beam turns, is placed in the centre of gravity of the beam, and if the fulcrum and the points of suspension are in the same right line, the balance will have no tendency to one position more than another, but will rest in any position it may be placed in, whether the scales are on or off, empty or loaded.

If the centre of gravity of the beam, when level, is immediately above the fulcrum, it will overset by the smallest action; that is, the end which is lowest will descend; and it will do this with more swiftness, the higher the centre of gravity is, and the less the points of suspension are loaded.

But if the centre of gravity of the beam is immediately below the fulcrum, the beam will not rest in any position but when level; and if disturbed from that position, and then left at liberty, it will vibrate, and at last come to rest on the level. In a balance, therefore, the fulcrum ought always to be placed a little above the centre of gravity. Its vibrations will be quicker, and its horizontal tendency stronger, the lower the centre of gravity, and the less the weight upon the points of suspension.

4. The friction of the beam upon the axis ought to be as little as possible; because, should the friction be great, it will require a considerable force to overcome it; upon which account, though one weight should a little exceed the other, it will not preponderate, the excess not being sufficient to overcome the friction, and bear down the beam. The axis of motion should be formed with an edge like a knife, and made very hard; these edges are at first made sharp, and then rounded with a fine hone, or piece of buff leather, which causes a sufficient bluntness, or rolling edge. On the regular form and excellence of this axis, depends chiefly the perfection of the instrument.

5. The pivots which form the axis or fulcrum, should be in a straight line, and at right angles to the beam.

6. The arms should be as long as possible, relatively to their thickness, and the purposes for which they are intended; as the longer they are, the more sensible is the balance. They should also be made as stiff and inflexible as possible; for if the beam is too weak, it will bend, and become untrue.

7. The rings, or the piece on which the axis bears, should be hard and well polished, parallel to each other, and of an oval form, that the axes may always keep its proper bearing, or remain always at the lowest point.

Very delicate balances are not only useful in nice experiments, but are likewise much more expeditious than others in common weighing. If a pair of scales with a certain load is barely sensible to one-tenth of a grain, it will require a considerable time to ascertain the weight to that degree of accuracy, because the turn must be observed several times over, and is very small. But if no greater accuracy was required, and scales were used which would turn with one-hundreth of a grain, a tenth of a grain more or less would make so great a difference in the turn, that it would be seen immediately.

The statera, or Roman steel-yard, is a lever of the first kind, and is used for finding the weights of different bodies, by one single weight placed at different distances from the prop or centre of motion D (fig. 7.). For the shorter arm DG is of such a weight as exactly to counterpoise the longer arm DX. If this arm is divided into as many equal parts as it will contain, each equal to GD, the single weight P (which we may suppose to be one pound) will serve for weighing any thing as heavy as itself, or as many times heavier as there are divisions in the arm DX, or any quantity between its own weight and that quantity. As for example, if P is one pound, and placed at the first division 1 in the arm DX, it will balance one pound in the scale at W; if it is removed to the second division at 2, it will balance two pounds in the scale; if to the third three pounds; and so on to the end of the arm DX. If any of these integral divisions is subdivided into as many equal parts as a pound contains ounces, and the weight P is placed at any of these subdivisions, so as to counterpoise what is in the scale, the pounds and odd ounces therein will by that means be ascertained.

The wheel and axle is a machine much used, and is made in a variety of forms. It consists of a wheel with an axle fixed to it, so as to turn round with it; the power being applied at the circumference of the wheel, and the weight to be raised is fastened to a rope which coils round the axle.

AB (fig. 9.) is a wheel and CD an axle fixed to it, and which moves round with it. If the rope which goes round the wheel is pulled, and the wheel turned once round, it is evident that as much rope will be drawn off as the circumference of the wheel; but while the wheel turns once round, the axle turns once round; and consequently

the rope by which the weight is suspended, will wind ounce round the axis, and the weight will be raised through a space equal to the circumference of the axis.

The velocity of the power, therefore, will be to that of the weight, as the circumference of the wheel to that of the axis.

That the power and the weight may be in equilibrio, the power must be to the weight as the circumference of the wheel to that of the axis.

It is proved by geometry that the circumferences of different circles bear the same proportion to each other as their respective diameters do; consequently the power is to the weight, as the diameter also of the axis to that of the wheel.

Thus, suppose the diameter of the wheel to be eight inches, and the diameter of the axis to be one inch; then one ounce acting as the power P, will balance eight ounces as a weight W; and a small additional force will cause the wheel to turn with its axis, and raise the weight; and for every inch which the weight rises, the power will fall eight inches.

The wheel and axis may be considered as a kind of perpetual lever, of which the fulcrum is the centre of the axis, and the long and short arms are the diameter of the wheel and the diameter of the axis. See fig. 10.

From this it is evident, that the larger the wheel, and the smaller the axis, the stronger is the power of this machine; but then the weight must rise slower in proportion.

A capstan is a cylinder of wood, with holes in it, into which are put bars, or levers, to turn it round; these are like the spokes of a wheel without the rim. Sometimes the axis is turned by a winch fastened to it, which in this respect serves for a wheel; and is more powerful in proportion to the largeness of the circle it describes, compared with the diameter of the axle.

When the parts of the axis differ in thickness, and weights are suspended at the different parts, they may be sustained by one and the same power applied to the circumference of the wheel; provided the product arising from the multiplication of the power into the diameter of the wheel, is equal to the sum of the products arising from the multiplication of the several weights into the diameters of those parts of the axis from which they are suspended.

In considering the theory of the wheel and axle, we have supposed the rope that goes round the axle to have no sensible thickness; but as in practice this cannot be the case, if it is a thick rope, or if there are several folds of it round the axis, you must measure to the middle of the outside rope, to obtain the diameter of the axis; for the distance of the weight from the centre is increased by the coiling of the rape.

If teeth are cut in the circumference of a wheel, and if they work in the teeth of another wheel of the same size, as fig. 11, it is evident that both the wheels will revolve in the same time; and the weight appended to the axle of the wheel B, will be raised in the same time as if the axle had been fixed to the wheel A. But if the teeth of the second wheel are made to work in teeth made in the axle of the first, as at fig. 12, as every part of the circumference of the second wheel is applied successively to the circumference of the axle of the first, and as the former is much greater than the latter, it is evident that the first wheel must go round as many times more than the second, as the circumference of the second wheel exceeds that of the first axle.

In order to a balance here, the power must be to the weight, as the product of the circumferences, or diameters of the two axles multiplied together, is to the circumferences or diameters of the two wheels.

This will become sufficiently clear, if it is considered as a compound lever, which was explained above. Instead of a combination of two wheels, three or four wheels may work in each other, or in any number; and by thus increasing the number of wheels, or by proportioning the wheels to the axis, any degree of power may be acquired.

To this sort of engine belong all cranes for raising great weights; and in this case the wheel may have cogs all round it, instead of handles; and a small lanthorn, or trundle, may be made to work in the cogs, and be turned by a winch, which will make the power of the engine to exceed the power of the man who works it, as much as the number of revolutions of the winch exceeds those of the axle CD, fig. 9, when multiplied by the excess of the length of the winch above the length of the semidiameter of the axle added to the semidiameter or half-thickness of the rope K, by which the weight is drawn up. Thus, suppose the diameter of the rope and axle taken together to be 13 inches, and consequently half their diameter to be $6\frac{1}{2}$ inches, so that the weight W will hang at $6\frac{1}{2}$ inches perpendicular distance from below the centre of the axle. Now, let us suppose the wheel AB, which is fixed on the axle, to have 80 cogs, and to be turned by means of a winch $6\frac{1}{2}$ inches long, fixed on the axle of a trundle of eight staves, or rounds, working in the cogs of the wheel; here it is plain, that the winch and trundle would make ten revolutions for one of the wheel AB, and its axis CD, on which the rope K winds in raising the weight W; and the winch being no longer than the sum of the semidiameters of the great axle and rope, the trundle could have no more power on the wheel than a man could have by pulling it round by the edge, because the winch would have no greater velocity than the edge of the wheel has, which we here suppose to be ten times as great as the velocity of the rising weight; so that, in this case, the power gained would be as 10 is to 1. But if the length of the winch is 13 inches, the power gained will be as 20 to 1; if $19\frac{1}{2}$ inches (which is long enough for any man to work by), the power gained will be as 30 to 1; that is, a man could raise 30 times as much by such an engine, as he could do by his natural strength without it, because the velocity of the handle of the winch would be 30 times as great as the velocity of the rising weight; the absolute force of any engine being in the proportion of the velocity of the power, to the velocity of the weight raised by it. But then, just as much power or advantage as is gained by the engine, so much time is lost in working it, which is common in all mechanical cases whatever.

In this sort of machines it is requisite to have a ratchet wheel on the end of the axle C, with a catch to fall into its teeth; which will at any time support the weight, and keep it from descending, if the person who turns the handle should, through inadvertence or carelessness, quit

his hold while the weight is rising. By this means, the danger is prevented which might otherwise happen by the running down of the weight when left at liberty.

The *pulley* is a small wheel turning on an axis, with a drawing-rope passing over it: the small wheel is usually called a sheeve, and is so fixed in a box, or block, as to be moveable round a pin passing through its centre.

Pulleys are of two kinds:—1. Fixed, which do not move out of their places: 2. Moveable, which rise and fall with the weight.

When a pulley is fixed, as fig. 13, two equal weights suspended to the ends of a rope passing over it, will balance each other; for they stretch the rope equally, and if either of them is pulled down through any given space, the other will rise through an equal space in the same time; and consequently, as the velocities of both are equal, they must balance each other. This kind of pulley, therefore, gives no mechanical advantage; so that you can raise no greater weight by it than you could do by your natural strength. Its use consists in changing the direction of the power, and sometimes enabling it to be applied with more convenience. By it, a man may raise a weight to any point, without moving from the place he is in; whereas, otherwise, he would have been obliged to ascend with the weight: it also enables several men together to apply their strength to the weight by means of the rope.

The moveable pulley represented at A (fig. 14), is fixed to the weight W, and rises and falls with it. In comparing this to a lever, the fulcrum must be considered as at A; the weight acts upon the centre, and the power is applied at the extremity of the lever D. The power, therefore, being twice as far from the fulcrum as the weight is, the proportion between the power and weight, in order to balance each other, must be as 1 to 2. Whence it appears, that the use of this pulley doubles the power, and that a man may raise twice as much by it as by his strength alone. Or it may be considered in this way: Every moveable pulley hangs by two ropes equally stretched, and which must, consequently, bear equal parts of the weight; but the rope AB being made fast at B, half the weight is sustained by it; and the other part of the rope, to which the power is applied, has but half the weight to support; consequently the advantage gained by this pulley is as 2 to 1.

When the upper and fixed block contains two pulleys, which only turn upon their axes, and the lower moveable block contains also two, which not only turn on their axis, but rise with the weight W (fig. 15), the advantage gained is as 4 to 1. For each lower pulley will be acted upon by an equal part of the weight; and because in each pulley that moves with the weight, a double increase of power is gained, the force by which F may be sustained, will be equal to half the weight divided by the number of lower pulleys; that is, as twice the number of lower pulleys is to 1, so is the weight suspended to the power.

But if the extremity C (fig. 16) is fixed to the lower block, it will sustain half as much as a pulley; consequently here the rule will be, as twice the number of pulleys adding unity is to 1, so is the weight to the power.

These rules hold good, whatever may be the number of pulleys in the blocks.

If, instead of one rope going round all the pulleys, the rope belonging to each pulley is made fast at top, as in fig. 17, a different proportion between the power and the weight will take place. Here it is evident, that each pulley doubles the power: thus, if there are two pulleys, the power will sustain four times the weight.

Fig. 8, is the concentric pulley, invented by Mr. James White. O, R, are two brass blocks, in which grooves are cut; and round these a cord is passed, by which means they answer the purpose of so many distinct pulleys. The advantage gained is found by doubling the number of grooves in the lower block.

It is common to place all the pulleys in each block on the same pin, by the aide of each other, as in fig. 18; but the advantage, and rule for the power, are the same here as in figs. 15 and 16.

A pair of blocks with the rope fastened round it, is commonly called a tackle.

[The above is the doctrine usually given in books to illustrate the theory of the mechanical power of the moveable block; but for the following ingenious and more simple method, we are in some measure indebted to a gentleman at Cambridge, England.

We call it *the moveable block*, because it is entirely erroneous to consider a pulley a mechanical power; as no advantage whatsoever is gained by the pulley itself, excepting that which merely arises from the abatement of the friction.

Axiom. The tension of the same string is the same though continued over any number of pullies.

Cor. In a fixed pulley, the power and the weight are equal; for the tension at B (fig. 13.) is equal to that at C.

It is evident, therefore, that the sole use of the fixed pulley is to change the direction of the moving power. But it is just the reverse in the moveable pulley or block, which adds to the moment of the power, but causes no change in its direction.

A weight is supported by a power with the assistance of a moveable block containing one pulley: To find the ratio between the power and the weight.

Let the power or tension of the string C (fig. 14) $= m$, the tension of F and E is each equal to m, but the strings F and E are spent in supporting the string for the weight, which therefore $= 2m$.

Consequently the power : weight $:: m : 2m :: 1 : 2$.

Cor. If the number of pullies in the moveable block $= n$, it may be found by a similar process that $P : W :: 1 : 2n$. Therefore, if the same string be continued over two blocks of pullies (figs. 15, 16, 18,) P will be to W as unity to the number of strings at the moveable block. The strings which support the moveable block, support each an equal share of the weight, and the power is equal to the tension of those strings.

Let the power (fig. 17) $= m$: to calculate the tension of the strings A, B, C, &c.

$$\text{The tension of} \begin{cases} A = m \\ B = m \\ C = m \\ D = 2m \\ E = 2m \\ F = 4m \\ G = 4m \\ H = 8m \end{cases}$$

Therefore $P : W :: m : 8m :: 1 : 8$.

Cor. In a combination of pullies of this kind, if the number of pullies $= n$, $P : W :: 1 : 2^n$. That is, as unity to that power of 2 whose index is the number of moveable blocks. We have generally observed, however, that mechanics, in the arrangement of tackle, especially on board of our vessels, prefer constructions different from those which have been noticed: and as these constructions have not, as far as we know, been exhibited in any treatise on the mechanical powers, we shall insert them, with the separate statement of the power gained.

In fig. 33, the tension of the strings 1, 1, is each equal to 1 and the tension of $2 = 2$; therefore the power : weight $:: 1 : 1 + 2 = 3$. The universal rule in this construction is, if $n =$ number of pullies both fixed and moveable, $P : W :: 1 : 2^n - 1$.

In fig. 30, the tension of the strings is represented by the figures, therefore $P : W :: 1 : 1 + 2 + 1 + 1 = 5$.

As in some cases it becomes desirable to be enabled with the same tackle to hoist heavy articles *with ease*, and also light ones *without loss of time*, a very advantageous method is adopted by means of a rope called a runner; which, when lighter goods are hoisted from the holds of vessels, is hooked to a staple on deck near the hatchway, and when heavy packages are to be raised, is hooked to *them*: as in fig. 31; if W be light, the runner A is attached to the staple C, and the power $= 3$; but if it be heavy, it is hooked with B, to W, and the power $= 7$. Whereas it is evident, that if A were always attached to B, the power 7, being greater than necessary to hoist smaller packages, a loss of time would follow; and if A were always hooked to the staple C, the power 3 would be less than efficient to raise heavy articles.

In fig. 32 the same effects follow, and by that construction the powers vary from 4 to 9.

It may be observed, generally, that in all constructions of pullies, the power is to the weight as the velocity of the weight is to the velocity of the power; or, which is the same thing, the space passed through by each in any given time. [*p*]

The *inclined plane*. This mechanical power is of very great use in rolling up heavy bodies, such as casks, wheelbarrows, &c. It is formed by placing boards, or earth, in a sloping direction.

The force wherewith a body descends upon an inclined plane, is to the force of its absolute gravity, by which it would descend perpendicularly in free space, as the height of the plane is to its length. For suppose the plane AB (fig. 12) to be parallel to the horizon, the cylinder C will keep at rest on any part of the plane where it is laid. If the plane is placed perpendicularly, as AB, fig. 20, the cylinder C will descend with its whole force of gravity, because the plane contributes nothing to its support or hindrance; and therefore it would require a power equal to its whole weight to keep it from descending.

Let AB (fig. 21) be a plane parallel to the horizon, and AD a plane inclined to it; and suppose the whole length AD to be three times as great as the perpendicular DB. In this case the cylinder E will be supported upon the plane DA, and kept from rolling, by a power equal to a third part of the weight of the cylinder; therefore a weight may be rolled up this inclined plane, by a third part of the power which would be sufficient to draw it up by the side of an upright wall.

It must also be evident, that the less the angle of elevation, or the gentler the ascent is, the greater will be the weight which a given power can draw up; for the steeper the inclined plane is, the less does it support of the weight; and the greater the tendency which the weight has to roll, consequently the more difficult for the power to support it: the advantage gained by this mechanical power, therefore, is as great as its length exceeds its perpendicular height.

To the inclined plane may be reduced all hatchets, chisels, and other edge-tools.

The *wedge* is the fifth mechanical power or machine: it may be considered as two equally inclined planes, joined together at their bases; then DG (fig. 22) is the whole thickness of the wedge at its back ABGD, where the power is applied; EF is the depth or height of the wedge, BF the length of one of its sides; and OF is its sharp edge, which is entered into the wood intended to be split, by the force of a hammer or mallet striking perpendicularly on its back. Thus, AB (fig. 23) is a wedge driven into the cleft CED of the wood FG.

When the wood does not cleave at any distance before the wedge, there will be an equilibrium between the power impelling the wedge downward, and the resistance of the wood acting against the two sides of the wedge, when the power is to the resistance as half the thickness of the wedge at its back is to the length of either of its sides; because the resistance then acts perpendicular to the side of the wedge. But when the resistance on each sides acts parallel to the back, the power that balances the resistances on both sides will be, as the length of the whole back of the wedge is to double its perpendicular height.

When the wood cleaves at any distance before the wedge (as it generally does), the power impelling the wedge will not be to the resistance of the wood as the length on the back of the wedge is to the length of both its sides, but as half the length of the back is to the length of either side of the cleft, estimated from the top or acting part of the wedge. For, if we suppose the wedge to be lengthened down from the top CE, to the bottom of the cleft at D, the same proportion will hold; namely, that the power will be to the resistance as half the length of the back of the wedge is to the length of either of its sides: or, which amounts to the same thing, as the whole length of the back is to the length of both the sides.

The wedge is a very great mechanical power, since not only wood, but even rocks, can be split by it; which it would be impossible to effect by the lever, wheel and axle, or pulley; for the force of the blow, or stroke, shakes the cohering parts, and thereby makes them separate more easily.

The *screw* (fig. 24.) is the sixth and last mechanical power, but cannot properly be called a simple machine, because it is never used without the application of a lever or winch to assist in turning it; and then it becomes a compound engine of a very great force, either in pressing the parts of bodies closer together, or in raising great weights. It may be conceived to be made by cutting a piece of paper, ABC (fig. 25), into the form of an incli-

ned pane, or half-wedge; and then wrapping it round a cylinder (fig. 26), the edge of the paper AC will form a spiral line round the cylinder, which will give the thread of the screw. It being evident that the winch must turn the cylinder once round, before the weight of resistance can be moved from one spiral winding to another; therefore, as much as the circumference of a circle described by the handle of the winch is greater than the interval or distance between the spirals, so much is the force of the screw. Thus, supposing the distance of the spirals to be half an inch, and the length of the winch twelve inches, the circle described by the handle of the winch where the power acts will be 76 inches nearly, or about 152 half inches, and consequently 152 times as great as the distance between the spirals: and therefore a power at the handle, whose intensity is equal to no more than a single pound, will balance 152 pounds acting against the screw; and as much additional force as is sufficient to overcome the friction, will raise the 152 pounds; and the velocity of the power will be to the velocity of the weight, as 152 to 1. Hence it appears, that the longer the winch is, and the nearer the spirals are to one another, so much the greater is the force of the screw.

A machine for showing the force or power of the screw may be contrived in the following manner:—Let the wheel C have a screw (fig. 24) on its axis, working in the teeth of the wheel D, which suppose to be 48 in number. It is plain, that for every time the wheel C and screw are turned round by the winch A, the wheel D will be moved one tooth by the screw; and therefore, in 48 revolutions of the winch, the wheel D will be turned once round. Then, if the circumference of a circle, described by the handle of the winch A, is equal to the circumference of a groove round the wheel D, the velocity of the handle will be 48 times as great as the velocity of any given point in the groove. Consequently, if a line G goes round the groove, and has a weight of 48 pounds hung to it, a power equal to 1 pound at the handle will balance and support the weight. To prove this by experiment, let the circumferences of the grooves of the wheels C and D be equal to one another; and then if a weight H, of 1 pound, is suspended by a line going round the groove of the wheel C, it will balance a weight of 48 pounds hanging by the line G; and a small addition to the weight H will cause it to descend, and so raise up the other weight.

If a line G, instead of going round the groove of the wheel D, goes round its axle 1, the power of the machine will be as much increased as the circumference of the groove exceeds the circumference of the axle; which supposing to be six times, then one pound at H will balance six times 48, or 288 pounds, hung to the line on the axle: and hence the power or advantage of this machine will be as 288 to 1. That is, a man who by his natural strength could lift a hundred weight, will be able to raise 288 cwts. by this engine. If a system of pulleys was applied to the cord H, the power would be increased to an amazing degree.

When a screw acts in a wheel in this manner, it is called an endless screw.

When it is not employed in turning a wheel, it consists of two parts: the first is called the male or outside screw; being cut in such a manner, as to have a prominent part going round the cylinder in a spiral manner, which prominent part is called the thread of the screw; the other part, which is called the female, or inside screw, is a solid body, containing a hollow cylinder, whose concave surface is cut in the same manner as the convex surface of the male screw, so that the prominent parts of the one may fit the concave parts of the other.

A very considerable degree of friction always acts against the power in a screw; but this is fully compensated by other advantages; for on this account the screw continues to sustain a weight, even after the power is removed, or ceases to act, and presses upon the body against which it is driven. Hence the screw will sustain very great weights: insomuch that several screws, properly applied, would support a large building, whilst the foundation was mending, or renewed.

OF COMPOUND MACHINES.

Though it is evident from the principles delivered above, that any of the mechanical powers is capable of overcoming the greatest possible resistance, in theory; yet, in practice, if used singly for producing very great effects, they would be frequently so unwieldy and unmanageable, as to render it impossible to apply them. For this reason, it is generally found more advantageous to combine them together; by which means the power is more easily applied, and many other advantages are obtained. In all machines, simple as well as compound, what is gained in power is lost in time. Suppose that a man, by a fixed pulley, raises a beam to the top of a house in two minutes, it is clear that he will be able to raise six beams in twelve minutes; but by means of a tackle, with three lower pulleys, he will raise the six beams at once, with the same ease as he before raised one; but then he will be six times as long about it, that is, twelve minutes: thus the work is performed in the same time, whether the mechanical power is used or not. But the convenience gained by the power is very great; for if the six beams are joined in one, they may be raised by the tackle, though it would be impossible to move them by the unassisted strength of one man.

Consequently, if by any power you are able to raise a pound with a given velocity, it will be impossible, by the help of any machine, to raise two pounds with the same velocity; yet, by the assistance of a machine, you may raise two pounds with half that velocity, or even one thousand with the thousandth part of that velocity; but still there is no greater quantity of motion produced, when a thousand pounds are moved, than when one pound is moved; the thousand pounds moving proportionally slower.

No real gain of force is, therefore, obtained by mechanical contrivances; on the contrary, from friction, and other causes, force is always lost; but by machines we are able to give a more convenient direction to the moving power, and to apply its action at some distance from the body to be moved, which is a circumstance of infinite importance. By machines also, we can so modify the energy of the moving power, as to obtain effects which it could not produce without this modification.

In machines composed of several of the mechanical powers, the power will be to the weight, when they are in equilibrio, in a proportion formed by the multiplication of the several proportions which the power bears to the

was the drachma, or eighth part of an ounce, of which Mr. Pinkerton describes the medial value to be ninepence sterling: the didrachm, tridrachm, and tetradrachm, explain themselves, except the tetradrachm of the Æginean standard, which was valued at five shillings. This last was the largest form of the Greek silver coins. The silver divisions of drachma were the tetrobolion, the hemidrachm or tribolion, the diobolion, the obolus, the hemiobolion, the tetrabolion, and dichalcos; the first of the value of sixpence, the last of a farthing and a half. Of the distinct names by which many of these coins were called among the different states, our intelligence is partial; nor are such names of consequence.

The next Greek coinage, in point of antiquity, is that of copper, which is said not to have been introduced till four hundred and four years before the christian æra. The first copper coin of Greece was the chalcos, of which two went to the quarter of the silver obulus. In days of poverty, however, even this was divided by different states into different portions, which were called λεπτα, or little coins. The lepton, dilepton, and tetralepton, were the divisions of the chalcos, the smaller of which, from their perishable size, are very rare. Such were the brass coins of Greece previous to the subjection of that country to the Roman empire.

The earliest of the gold coins of Greece are those of Philip of Macedon, although they were struck in Sicily considerably earlier. Philip, having conquered the city Crenides, on the confines of Thrace, found gold-mines in its neighbourhood, formerly ill explored, and of small produce. From this gold he first struck the coins called Philippi, because of his portrait which appears on them. The Philippi it should seem were didrachms, the form most universal in the ancient coinages of gold; and at their first appearance went for 20 silver drachmæ, but in latter times for 25 Greek drachmæ, or Roman denarii. The Philippus was also called Χρυσος. There were likewise the ημιχρυσος and the τεταρτοχρυσος, with gold coins of Cyrene, which could not have gone for more than two drachmas of silver. There were also the Δι χρυσος and the Τετραςηρ, or quadruple χρυσος; the former worth about two, and the latter worth about four pounds of our money.

The original value of the Roman coins is a subject still more intricate and extensive. As in Greece, the first estimation of their money was by weight; though copper, not silver, was the first medium of coinage. The first Roman coinage, according to Mr. Pinkerton, was in the reign of Servius Tullus, about the year 460 before the common æra, and was confined to the as or æs libralis, or piece of brass only, which was stamped with the two faced head of Janus on the one side, and the prow of a ship on the other; though Mr. Pinkerton afterward thinks it probable that the very first Roman ases of Tullus had the figure of a bull, ram, or other species of cattle. However this may be, parts of the as were very early given in proportion of weight and value: such were the semis or half, the triens, the quadrans, the sextans, and the uncia. After a certain period, the as, though still called libra, fell to two ounces; and as it fell in weight, larger denominations were coined. Such were the bissus or dupondius, the tressis, the quadrussis, and even the decussis, or piece of ten ases in copper.

When the Romans began, by intercourse with Greece, to imbibe the arts of elegance, a variety of types appeared upon the parts of the as, and at length upon the as itself; though these, it is believed, are not seen till near the time of Sylla. Dupondii, or double ases, were also coined in the later period of the commonwealth, as in the former; together with the sestercii æerei, which came in place of the quadrusses. It must also be observed that the Romans, in some instances, accommodated their coins to the country in which their army was stationed; so that it is from the coins struck at Rome only that the coinage can be adjusted.

The largest of the imperial brass coins, according to our author, was the sestercius, worth about twopence English; no sensible diminution of which from its first weight of an ounce took place till the reign of Alexander Severus, when it lost upwards of a sixth. In the time of the Philippi, it was still more reduced; and under Trajanus Decius it had lost near a half. He was the first prince who seems to have coined double sestercii, or quinarii of brass, for such are the common medallions inscribed FELICITAS SAECVLI, or VICTORIA AVG., which just weigh double his sestercii, and little more than the sestercii of the early emperors. From Trebonianus Gallus down to Gallienus, when what is called the first brass ceases, the setercius does not weigh above one-third of an ounce; any larger are double sestercii, or medallions struck upon uncommon occasions. After Gallienus, the sestercius totally vanishes. Under Valerian and Gallienus, a new coinage appears of what were called denarii æris, or Philippei æria of copper washed with silver. In the reign of Diocletian, the follis supplied the place of the sestercius; and soon after we find the denarius æreus dropped for ever. Such was the progress of the largest form of the imperial brass coin of Rome.

The dupondius, being half the sestercius, was the next in value. Prior to Augustus, it seems to have been commonly struck in copper; though after his time it was struck in yellow brass. It kept pace with the sestercius in all its stages.

The imperial as or assarium is the next coin. It began to be called assarium as soon as its size was reduced to half an ounce, and, like the dupondius, diminished gradually in its form, till at the end of Gallienus's reign it became what is called small brass. The parts of the as, says Mr. Pinkerton, in the imperial times, are, generally speaking, very rare. However, of Nero, there are the semis, triens, quadrans, sextans, and uncia, being all the parts; and of Domitian there are the same.

From Pertinax down to Gallienus, there is no small brass save of Trajanus Decius. With Gallienus it becomes extremely common. Toward the end of his reign the assaria were diminishing to a still less size. Farther we shall not trace this branch of the coinage.

The silver coinage of Rome is supposed first to have taken place about 266 years before the christian æra. The most ancient denarii are those on which no inscription, save the word ROMA, appears: and at that time the denarius seems to have gone for ten ases: though it was afterward raised to sixteen, till the time of Gallienus. Under Caracalla, when the silver coinage was debased, denarii were struck of two sizes; the larger bearing an increase of value by a third. Both, however, lessened by degrees till after Gordian III. when the smaller total-

ly vanished, and the larger alone remained. The latter, in the time of Gallienus, was the sole denarius of silver, and probably gave rise to the denarii æreí, which have been already mentioned. Such was the silver coinage till the time of Constantine the First, when the milliarensis was introduced, weighing about 70 grains, and answering in worth to our shilling. The denarii or argentei were, however, still coined, and were the money most common in currency.

Of the smaller silver coins of Rome, two only remain to be mentioned, the quinarii or pieces of five ases, and the sestercii of silver, which seem to have been coined down to Augustus.

Gold, we are informed by Pliny, was first coined at Rome in the 204th year before the present æra; and his account of the diminution in weight which marked the progress of its coinage, is singularly coroborated by such coins as have come down to us. The scruple, he says, went for 20 sesterces. "It was afterward thought proper to coin 40 pieces out of the pound of gold. And our princes have by degrees diminished their weight to 45 in the pound." Till Sylla's time, the aureus continued at 30 denarii; it afterwards fell to 20; though both under Claudius and Severus we find it at 25. Constantine the First, instead of the aureus, gave the solidus, of six in the ounce of gold, one of which answered to 14 of the miliarenses. The solidus continued of the very same standard to the close of the Byzantine empire.

Of the potraits which are to be found on coins, those of the kings of Macedon have the first rank, as their coins have the greatest antiquity of any yet discovered on which portraits are found. Alexander I. begins the series, who reigned 501 years before the christian æra. Then follow the kings and queens of Sicily, Caria, Cyprus, Pontus, Egypt, Syria, Thrace, Bithynia, &c. extending in series from the time of Alexander the Great to the birth of Christ, comprising a period of about 330 years. In this class are placed the beautiful coins of the Seleucidæ. The last series of ancient kings goes down to the fourth century, including those of Mauritania and Juda; and finishing the series of the portraits of kings found on medals struck with Grecian characters.

The Roman emperors present a most distinct series from Julius to a later period than the destruction of Rome by the Goths.

The kings, upon Greek coins, have generally the diadem, without any other ornament, usually with a side face, and almost always in very high relief; though several, particularly the beautiful gold coin of Ptolemy Philadelphus, others of Antony and Cleopatra, &c. have more portraits than one upon them. The chief ornament of the portraits is the diadem or vitta. The radiated crown, a mark of deification, on the posthumous coins of Augustus, was, in a little more than a century after, put upon most of the emperors' heads in their several medals. The crown of laurel is continually seen: and Agrippa appears not only with the rostral but the mural crown. The successors of Alexander assumed, by way of distinction, different symbols of deity on the busts of their medals. A few instances also occur, among the Roman coins, of the helmet.

The reverses of medals, both among the Greeks and Romans, were of infinite variety. They contain figures of deities at whole length with their attributes and symbols; public buildings and diversions; allegorical representations; ceremonies; historical and private events; figures of ancient statues; subjects of natural history; magistracies, &c. The reverses of the Roman coins have more of art and design than the Greek, though the latter have more exquisite relief. In the very ancient coins no reverse is found, and of the ancient Greek reverses some are in intaglio. The figures of deities and personifications on the Roman coins, are commonly attended with the names: as, the figure of Virtue with VIRTVS AVGVSTI: but on the reverse of the Greek coins the figure is only accompanied by some certain symbol; as Ceres with her wheaten garland, Mars with his armour, or Mercury with his caduceus. The anchor on Seleucian coins is the mark of Antioch; the owl, of Athens; the labyrinth, of Crete; the horse, of Thessaly; and so on.

Of the legends, the early Greek coins usually contain the name or the initials of the city they belong to; or the name, the first character of it, or the monogram, of the prince. The earliest coins of Athens have only ΑΘΕ, money of Athens; ΣΥ, of Sybasis; ΜΑΣ, of Massilia. ΣΥRΑΚΟΥΣΙΩΝ occurs at full length, as well as ΦΙΛΙΠΠΟΣ for Philip of Macedon. And though in aftertimes the names of princes were accompanied by modest adjuncts, there were others that were not a little proud. Of the former were ΔΙΚΑΙΟΥ ΕΥΣΕΒΟΥΕ ΦΙΛΕΛΛΗΝΟΣ; of the latter, ΘΕΟΠΑΤΟΡΟΣ ΒΑΣΙΛΕΩΣ ΒΑΣΙΛΕΩΝ, &c.

After the Roman empire had swallowed up the Grecian, the legends on Greek coins became as remarkable for length as they had been before for brevity. The Greek imperial coins have a great variety in their legends. Nor are many of the reverses wanting in adulation. The legends of the Roman imperial coins are still more deservedly celebrated for their beautiful simplicity. IVDEA CAPTA and ASIA SUBACTA are sufficient instances.

Of the pieces produced by the ancient mints, there were some of a size which showed them evidently to have been intended for something else than circulation. Medallions were occasionally presented by the emperor to his friends; and sometimes by the mint-master to the emperor as specimens of workmanship. These are usually known by their weight, which is far greater than that of the acknowledged money. Both the Greek and Roman medallions appear to have been principally struck in the imperial periods. Till the time of Hadrian they are rare. For a more full account of them, we refer to the work of Mr. Pinkerton.

To dwell longer on the various types either of the Grecian or the Roman coins, would be surperfluous. Their curiosity and elegance are infinite. The regal coins of Greece are interesting from their portraits; the coins of cities, from their importance to geography. On the consular coins of Rome, the names and titles of the consuls do not appear till toward the close of the series: the brass consular coins are uninteresting. The imperial brass is of three sizes, large, middle, and small; the first forming a series of the greatest beauty. The imperial silver coins are numerous; the gold, of wonderful perfection. For the different abbreviations which

occur both upon the Greek and Roman coins, we shall refer to the Tables selected by Mr. Pinkerton, as it would be impossible, in so concise a work as this, to give every information which the collector might require. The best works upon the Greek and Roman coins are probably these: Froelich's Notitia Elementaris; Neuman's Populi and Reges inediti; the Works of Pellerin; the Nummi populorum et urbium Magnæ Græciæ, by Dr. Combe; Havercamp on the Consular Coins; and the Roman Imperial, by Valliant, edition 1745, by Valdini, with the Supplement by Kehl.

Of the early British coins, previous to the arrival of the Romans, we know but little. They were probably like the ancient Gaulish, rudely ornamented, and without inscriptions. Those which we usually call British, were evidently the work of Roman moneyers. Those with CVNO on one side, and CAMV on the other, are usually ascribed to Cunobelin, the king of the Trinobantes. There is also one which has a bull on the obverse, with V. E. R. V. L. A. M. I. O. for the legend, apparently struck at Verulam. The meaning of *taseia*, which is common both to the Gallic and the British coins, wants explanation.

Of the coins of the Saxon heptarchy, there are but two descriptions: the sceatta, or penny, and the styca; the latter of which seems to have been principally confined to the kingdom of Northumbria. Of the coins of the heptarchic princes, the series is very far from regular; and of one or two princes unique specimens only are known. Of the chief monarchs, Ethelbald and Edmund Ironside are the only two who break the series. Of their coinage we have no specimens. The obverses of all these bear merely the resemblance of a human bust; though the reverses are occasionally interesting. The inscriptions also are sometimes peculiar, and we have a few specimens in the ninth century of archiepiscopal coinage. The best guide to the collector of Anglo-Saxon coins will be found in the plates of Dr. Hickes's "Thesaurus;" their rarity and value may be learnt from the Essay we have so often quoted.

The two first kings after the Conquest coined only pennies, the types of which are different, though in point of weight and goodness they agree with the pennies of the Saxons: their weight was usually 22 grains and a half. The obverse represents sometimes the full, and sometimes the side face of the sovereign, with the name of the mint-master and town of mintage on the reverse. To pennies, Henry the First added halfpennies, though none of them have reached us. King Stephen's pennies were of the same value as those of his predecessors. There are also some extant, which have the name of Eustace on them. Stephen's son; and one occurs with the head and title of Henry bishop of Winchester, the king's base brother. Those of Stephen which have the banner are the rarest. The pennies of Henry the Second are also scarce; of Richard the First we have only the French penny; and of John no money but what was coined in Ireland; though of the last there are not only pennies but halfpennies and farthings. The first coinage of Henry the Third had only on the obverse HENRICVS REX, and his pennies till within these 30 years were usually ascribed to Henry the Second. After his 32d year, we find III or TERCI added to the title. The pennies, halfpennies, and farthings of Edward the First are all common. Such pennies as have EDW. R. ANGL. DNS. HYB upon the obverse, are usually ascribed to Edward the First; those with EDWA. or EDWAR. to Edward the Second; and those with EDWARD or EDWARDVS to Edward the Third. This, however, is but conjecture. In the 18th of Edward the Third, the penny was brought down to 20 grains; and in his 27th year, we find groats and half-groats coined, in which the king's head was surrounded by a sort of double treasure. In the reign of Edward the Fourth, having previously sunk to 15, the penny fell to 12 grains. In Edward the Sixth's time, it was reduced to eight, and in Elizabeth's to little more than seven. Of the groats, Richard the Third is very rare. In 1503, Henry the Seventh coined the shilling or testoon: it resembled the groat, but was larger, and weighed no less than 144 troy-grains. The crown of silver was first struck by Henry VIII. and the half-crown sixpence, and threepence, by Edward the Sixth. Elizabeth, in 1558, coined three-halfpenny, and in 1561, three farthing pieces; but they were disused in 1582. Henry the Eighth was the first of our princes who debased the coinage; and in the earlier part of Edward the Sixth's reign, the practice was continued: but from the 43d of Elizabeth, 1601, the denomination, weight, and fineness of English silver, have remained the same. From 1561 to 1568, the money of Elizabeth was coined in a better taste, by means of a mill and screw, but the artist of this money being hanged for counterfeiting coins, the hammering system was again recurred to. Till the time of Charles the second, we have little more of the milled money.

The design of a gold coinage appears to have been first formed by Henry the Third, the most particular account of which is to be found in lord Liverpool's Letter to the King. The piece ordered to be current was called a gold penny; but being of too great value for general circulation, it was in two or three years called in, and now but three specimens remain. In itself, the gold penny is a beautiful specimen of the coinage of the time. The obverse is much in the manner of the king's great seal, and the inscription Henricus Rex III.; on the reverse, the mint-master's name and place. The three known are all of different types: one reads LVND, another LVNDE, and the third LVNDEN. But it is from Edward the Third that the series of our gold coins commences. In 1344, he struck the florin, half, and quarter florin. The florin was current for six shillings, but was the same year succeeded by the noble, the value of which was half a mark. Henry the Fifth diminished the value of the noble; Henry the Sixth restored it to its size, and gave it the name of ryal; while Edward the Fourth, in 1465, supplanted it with the angel. Henry the Eighth, in 1523, added the gold crown and half crown at their present value: the sovereign of 22*s.* 6*d.*; the ryal at 11*s.* 3*d.*; the angel at 7*s.* 6*d.*; and the noble at its old value. In 1546, he coined sovereigns and half-sovereigns, the former to go at 20*s.* and the latter in proportion. Charles the Second, however, instead of the sovereign, introduced the guinea and half-guinea. George the Frst added the quarter-guinea. But though it was continued in the early part of the reign of his present majesty, the seven-shilling piece has been preferred.

The history of our copper coinage, the last in order of chronology, will be shorter. From the reign of Henry the Eighth till the close of queen Elizabeth's reign, the scarcity of silver farthings and halfpence gave rise to the introduction of tokens or pledges for money among tradesmen, many of which are undoubtedly alluded to in what has been said by Erasmus and other writers about leaden money. Elizabeth, it appears, would never hear of a copper coinage for the country: and though farthing tokens of copper were issued both by James and Charles the First, they were considered rather as pledges of government than legitimate money. The death of Charles the First put an effectual stop to their farther currency: and till 1672, the country again swarmed with town pieces and tradesmen's pledges; when, in the latter year, halfpence and farthings of copper were made public money, and the circulation of tokens forbidden. His present majesty has added two-penny pieces.

MEDEOLA, *climbing African asparagus*, a genus of the hexandria order, in the trigynia class of plants, and in the natural method ranking under the 11th order, sarmentaceæ. There is no calyx; the corolla is sexpartite and revoluted; the berry trispermous. Its characters are these: the flower has no empalement; it has six oblong oval petals, and six awl-shaped stamina terminated by incumbent summits; and three horned germina terminating the style; the germina afterward turn to a roundish trifid berry with three cells, each containing one heart-shaped seed. There are three species.

MEDICAGO, *snail-trefoil*, a genus of the decandria order, in the diadelphia class of plants, and in the natural method ranking under the 32d order, papilionaceæ. The legumen is compressed and screwed; the carina of the corolla luring down from the vexillum. There are eleven species. They are low trailing plants, adorned with small yellow flowers, succeeded by small round snail-shaped fruit, which are downy, and armed with a few short spines. They are all easily propagated by seeds. The M. sativa or lucern, has been latterly much recommended as a green fodder for cattle, and has been cultivated by some farmers with success.

MEDICINE, is the art of preserving health, and of curing or alleviating disease. It is the same science in its application to animal, as agriculture to vegetable, life.

Origin and progress of medicine. "Medicina nusquam non est." This art arises out of the natural, as others more gradually and indirectly originate from the artificial and adventitious, wants of mankind. The exact period, however, in which medicine began to be formally practised as an art, or separately cultivated as a profession, has by no means been accurately ascertained. All the accounts which have been transmitted on this subject from a date prior to the time of Hippocrates are either conjectural or fabulous. Hippocrates first effected a separation of medicine from philosophy and religion, and gave it the form of a distinct science: he has therefore been generally regarded by the moderns as the father of physic; and from his time the history of this science may be made with propriety to commence.

Hippocrates was a native of Greece. He was born in the island of Cos, and flourished about 400 years prior to the christian æra. Of his character as a physician, an estimate cannot, confessedly with much accuracy, be formed from his writings, or from those works which have been attributed to him, but which are generally regarded as in a great measure the inventions of his disciples and successors. "Hippocrates," says a modern author, "lived at too early a period to be acquainted with the collateral branches of science. He studied life and disease in the book of nature, and had the merit of an original observer." We do not, however, feel disposed with this author fully to acquit the "Coan sage of the many idle theories which have been imputed to him." It may well be conceived that he was influenced in his opinions on the cause of disease and on the nature of healing, if not by the splendid fictions of the Greek philosophy, by preconceived theory and vague conjecture. Indeed, the hypotheses contained in the reputed writings at least of Hippocrates, have been, with trivial modifications, the hypotheses of modern times; for in this author's pervading and presiding principle of nature, and in his attraction, depuration, decoction, and crisis of disease, may be traced the same mode of theorizing which has been adopted by later systematics.

The humoral pathology, and even the *vis naturæ medicatrix* of modern times, appear to be modifications or relics of Hippocratic reasoning.

The immedediate successors of Hippocrates began to direct their researches into the auxiliary departments of medicine; and among these, Praxagoras, Chrysippus, Hirophilus, and Erasistratus, particularly the two last, made no inconsiderable discoveries (when we consider the scantiness of their materials) respecting the structure and functions of the human frame. It was about this period, according to Celsus, that the science was divided into the three distinct branches of dietetical, pharmaceutical, and chirurgical medicine—"una quæ victu, altera quæ medicamentis, tertia quæ manu mederetur." Shortly after the time of Herophilus, the medical world became divided into the two sects of empirics and dogmatists: the one, rejecting the reasoning and deriding the practice of their predecessors, affected to disregard all authority but that of experience; the other, retaining their faith in the scholastic philosophy of the times, and their conviction of the utility of physiological knowledge in detecting the causes and regulating the treatment of disease. The empiric sect was founded by Serapion of Alexandria, about 287 years before Christ.

The next revolution of importance in the medical art was occasioned by the introduction of the European philosophy into the schools of medicine. This was effected by Asclepiades, who was succeeded by Themison, the founder of the methodic sect, the members of which were equally hostile to the dogmatists and empirics. They discarded what they considered the occult reasoning of the former, and substituted in the room of the laborious observations of the latter, indications of treatments deduced from the analogy of diseases, or the mutual resemblance they bear to each other, "nullius causæ notitiam quicquam ad curationes pertinere; satisque esse quædam communæ morborum intueri methodici contendunt." *Celsus.* The most celebrated of Themison's followers were Thessalus, who flourished under the emperor Nero, and Soranus, a native of Ephesus, who lived during the time of the emperors Trajan and Adrian.

We have now arrived at a very conspicuous æra in

the science of medicine. About the 131st year after Christ, in the reign of Adrian, lived the celebrated Galen, who was born at Pergamus. At this time the dogmatic, empiric, and methodic sects of physicians had each their advocates. The methodics, however, were held in greatest estimation. Galen undertook the reformation of medicine, and affected to restore the Hippocratic philosophy and practice. Instead, however, of abiding by the doctrines of his master, his systems were almost entirely of his own invention. "Philosophy and science had now made some advances; and from those sources Galen introduced many corruptions into medicine." Like Hippocrates, he supposed the existence of four humours, from the predominancy or deficiency of one or other of which the varieties of constitutions, and likewise the complexion and nature of disease, were conjectured to originate. These humours are, in the Galenic system, the blood, the phlegm, the yellow bile, and the black bile. He likewise establishes three distinct kinds of spirits—the natural, the vital, and the animal; the first of which he supposes to be a subtile vapour arising from the blood; this, conveyed to the heart, becomes, when conjoined to the air taken into the lungs, the vital spirits, which are changed into the animal kind in the brain. These three species of spirits our author imagined to serve as instruments to distinct faculties: the natural faculty, which he supposed to reside in the liver, and to preside over the nutrition, growth, and generation of the animal body; the vital faculty, which he lodged in the heart, and imagined that through the intervention of the arteries it communicated warmth and preserved life; while the animal faculty, according to Galen, has its seat in the brain, is the cause of motion and sensation, and presides over all the other faculties. The origin or principle of motion in these respective faculties, Galen, as well as Hippocrates, calls *nature*.

The authority of Galen, notwithstanding the tissue of extravagances and idle conjectures of which his systems were formed, continued to prevail until the downfal of the Roman empire. The seat of learning now became the theatre of war, and the arts of peace took refuge in the Eastern nations. The Arabian succeeded to the Greek and Roman physicians, and still farther obscured the theories of medicine by the introduction of fresh absurdities. Anatomy was totally neglected, or at least not in any measure advanced, by the Saracens: they made some progress in the science of botany, and introduced several new drugs, principally of the aromatic kind, from the East, which retain still a place in the materia medica.

The mention of a singular controversy which occurred among the Arabian physicians, may serve to indicate the complexion of the times in relation to the dogmas and practice of physic.

Hippocrates had directed that in pleurisy blood should be drawn from the arm of that side which might be principally affected. Some of the Arabians contended that it should be taken from the side opposite; and such was the medical ignorance and fanaticism of the age, that a decree was issued from the university of Salamanca in Spain, forbidding any one to pursue the practice of Hippocrates. The members of this university even endeavoured to procure an edict from the emperor Charles V. to confirm their authority, alleging, that the practice they opposed was no less pernicious to medicine than Luther's heresy had been to religion!

From the time of the decay of learning to the commencement of the 16th century, the history of medicine furnishes no particulars of interest. This last is the period which gave birth to the celebrated Paracelsus. Now, all the facts and doctrines of medicine came to be explained by, and founded upon, imaginary principles of chemical philosophy. The ancient authors fell into disrepute; and the elements, qualities, and temperaments of the Greeks, were melted down and dissipated in the laboratory of the chemist. Fermentation, effervescence, ebullition, and deflagration with salts, sulphur, alkali, and mercury, came now to be familiarly, but without any precise signification, introduced among the terms of the medical art. With several, however, the Galenic philophy continued to prevail.

In the year 1628, Dr. W. Harvey, of London, first demonstrated and communicated to the world the most important fact of the circulation of the blood. This discovery afforded a new foundation for the whole structure of medical and physiological reasoning. Even this, like all other improvements in science, and bold innovations of established doctrines, met with very cold encouragement by the contemporaries of Harvey. It is said, that no physician or teacher of medicine, who had attained his 40th year, would subscribe to the fact; and that in thus conferring an incalculable benefit on the community, Harvey diminished his own contemporary reputation, and nearly lost his practice as a physician.

While some were industriously endeavouring to controvert the fact, others were busied in attempts to wrest the discovery from its author.

Servitus, a native of Spain, had, many years previous to the time of Harvey, published a Treatise on Medicine and Theology. In this work it is asserted, or rather perhaps conjectured, that the blood, by some unknown channel, passes from the pulmonary arteries into the veins. Even allowing that this intimation justly laid claim to the title of a discovery, it is merely a discovery of the passage of the blood through the lungs, and could in no measure interfere with the merit or be regarded as an anticipation of the Harveyian doctrine.

The period, however, had not yet arrived when a rational use was to be made of the important fact in question. As the alchemists had derided the Galenists, so the reasonings of the latter were now to give way to the mathematical sect of physicians, who by axioms, postulata, theorems, problems, experiments, and corollaries, ("a capite ad calcem armatos, et necem undique minitantes,") attempted to explain, in the most futile manner, the functions of life, and to regulate the remedial process.

The learned and industrious Boerhaave, of Leyden, whose name stands conspicuous in the annals of medicine, at length attempted to restore the authority of the ancient writings; and by uniting the doctrines of Hippocrates with the philosophy of the times, he framed a theory of medicine upon the supposition of acrimony, lentor, and other changes in the circulating fluids. From these changes he inferred the origin of all disease; and the process of cure is, according to Boerhaave, either the process of correcting or expelling acrimony from the body, or the correction of morbid viscidity or tenuity in

the humours. Boerhaave has, therefore, been considered the founder of the humoral pathology; a pathology which even to this day retains a material influence on the opinions, the phraseology, and the practice at least of the vulgar.

Contemporary with Boerhaave was the illustrious Hoffman, a German professor, and founder of a medical system. Dr. Staahl having first suggested, or rather borrowed from the ancients, the idea of the rational soul of man governing and directing the whole economy of his body, and obviating the adverse tendency of noxious agents by exciting such actions in the system as are calculated to effect their expulsion, or destroy their malignity; Hoffman endeavoured to demonstrate, that the first operation of the causes creating disease was the production of universal atony or spasm in the primary moving power of the system, and did not consist of changes produced either in the quantity or quality of the humours or fluids of the body, as taught by the celebrated Boerhaave.

The humoral, however, continued to prevail over the pathology of Haffman; and Dr. Cullen informs us, that "when he came to take a professor's chair in the university of Edinburgh, he found the Boerhaavian system then in its full force." In framing a system of his own, Dr. Cullen reverted to the theory of Hoffman; and indeed the whole of his pathology, as far as it relates to leading systematic doctrines, is scarcely any thing more than an attempt to unite the hypothesis of Hoffman with with the Stahlian principle of an intelligent, presiding, and preservative power.

We have thus rapidly conducted our readers over the ground of medical history, and have presented a faint outline of the prevailing systems of medical philosophy, from the time of the Grecian to the time of the "English Hippocrates;" to the period when the fanaticism and prejudice of system were shortly to give way before the precepts of genuine philosophy and temperate induction; when the medical science was to be established upon a new foundation; when chemistry was to undergo a reformation equally radical and important; when by consequence a new alliance was to be formed between these two sciences; when the language of metaphor and hypothesis was to be discarded from either; and when inquirers after truth were to be influenced and directed by the independant and invaluable maxim, "Nihil in intellectu quod non prius in sensu."

On nosology, or the classification of diseases. Dr. Sydenham was the first who proposed to adopt a division of diseases into class, order, and genus, upon similar principles with those of botanical arrangement. The idea has been followed out by several of Sydenham's successors, but by no means with that success which had been anticipated. The reason why nosologists have in some measure failed, is sufficiently obvious. While the objects of natural history possess a certain degree of uniformity, enabling the systematic to identify in a manner certain individuals, and thus to refer them to one class, scarcely any thing of this order is observed, or at least not sufficient to justify arrangement of the infinitely diversified phenomena of disease. For example: a certain series of symptoms shall present themselves during the life of an individual, which shall prove to have depended upon, or at least have been connected with, disordered condition of some particular organ. A careful register of such symptoms might be supposed to furnish the same guide to the pathologist and physician, as a recollection of the prominent character of a plant to the botanist or agriculturist. This, however, is by no means the case. Similar symptoms are not invariably characteristic of similar disorders. A cough may originate at one time from circumstances which would at another time suppress it. A catarrh of the nostrils will now be produced by a deficient, now by an excessive, action of precisely the same membrane. The generic terms then which are introduced into medicine, are extremely fallacious: they in fact convey no idea of the precise nature of that affection which they have been employed to indicate; and the difficulty is still greatly augmented when we recollect the endless diversities that must arise from the varied external circumstances, as affecting and modifying the constitutional character of the same individual.

A disease, then, as indicated by name, and described by signs, is in some measure an imaginary existence. Dr. Brown, the outline of whose doctrines is elsewhere exhibited (see the article Brunonian System), aware of the errors attached to nosology founded on symptoms, proposed to comprehend all morbid affections under the two leading divisions of diseases of increased and diminished excitement. Our author, however, in his opposition to particulars, went over to the other extreme of too indiscriminate and hasty generalization. The human frame is too complicated to admit of the simplification which Brown aimed at. His division is a guide to principle but not to practice.

A recent attempt has been made to include in one scheme both general principles and particular facts. This plan, however, notwithstanding the boldness of conception by which it was formed, and extraordinary ingenuity by which it has been executed, is defective. It rests upon a hypothetical, and therefore upon a sandy, foundation. Our readers who are acquainted at all with modern medicine, will be at no loss to conclude that we refer to the system of the late Dr. Darwin. By this author, excitability, which was left as an ultimate fact in the Brunonian theory, is attempted to be traced to its origin. The sensorial power, excitability, or spirit of animation, is conceived to be "a subtle fluid, residing in the brain and nerves, and liable to general or partial accumulation." The vital changes effected by the medium of this imaginary fluid, are, 1st, "Irritation, which is an exertion or change of some extreme part of the sensorium residing in the muscles or organs of sense, in consequence of the appulses of external bodies. 2. Sensation, an exertion or change of the central parts of the sensorium, or of the whole of it, beginning at some extreme parts of it, which reside in the muscles or organs of sense. 3. Volition is an exertion or change of the central parts of the sensorium, or of the whole of it, terminating in some extreme parts of it, which reside in the muscles or organs of sense. 4th. Association is an exertion or change of some extreme part of the sensorium, residing in the muscles or organs of sense, in consequence of some antecedent or attendant fibrous contractions."

With these assumptions as his guide, Dr. Darwin endeavours to penetrate deeper into the cause of disease

than is allowed by a mere knowledge of the condition of the fibre. The powers of the sensorium are the proximate cause; the fibrous action, the excitement of Dr. Brown, the proximate effect; and hence, from an ingenious, but by no means satisfactory, statement of the mode in which excitations are produced, he treats of diseases as occasioned by the comparative redundancy or deficiency of the sensorial power of irritation, sensation, volition, or association.

It would carry us far away beyond our limits to pursue this theory through the minutiæ of its ramifications. Some opportunities will be afforded in the course of the present article to acknowledge the obligations which medicine is under to its ingenious framer. We shall here confine ourselves to the statement of what we consider fundamental objections to the doctrines, and, by implication, the nosology or arrangement of Zoonomia.

In the first place, it does not distinguish between cause and effect, between fibrous motion and its source. Secondly, it substitutes, like the ancient systems, mere statements of phenomena for explication of their origin. Thirdly, and what is more immediately applicable to our present inquiry, it divides that which in its nature is indivisible.

Dr. Brown had defined excitement to be a certain state of fibrous action produced by the exciting powers acting upon the excitability. Dr. Darwin after him considers irritation or excitement as an exertion of the spirit of animation, exciting the fibres to contraction. Here we observe the want of precision alluded to, and the confusion originates from forsaking induction to embrace hypothesis. "On Dr. Darwin's principles the identical fibrous motion exists before the faculty of irritation can be exerted." The spirit of animation ought to have been stated as the unknown medium ("quo pacto adficiatur ignoratur") through which the excitement or irritation is produced.

Again, the sentient and fibrous changes which in the Darwinian system of life are thus connected, are not rendered more explicable by the intervention of a subtle fluid. The spirit of animation of Darwin, allowing its existence to be capable of proof, in no measure facilitates the conception of vital causation. As an exemplification of the last of the above objections, it may be urged, that when Dr. Darwin, in forming his classification, referred all morbid affection to the heads of irritation, sensation, volition, and association, he seems to have overlooked his former assumption, founded upon the inseparability and identity of the sensorial power or fluid. and not to have been aware he had already asserted that "propensity to action, whether it be called irritability, sensibility, voluntarity, or associability, is only another mode of expressing the quantity of sensorial power residing in the organ to be excited."

An increase then or diminution of one of these energies necessarily supposes an increase or diminution of all, "and the disorder of decreased irritability, ought also to be the disorder of decreased sensibility, voluntarity, and associability." The classification, then, is even in contradiction to the principles of Zoonomia. It is intricate and erroneous.

Perhaps the most consistent and comprehensive plan of arranging individual diseases would be that which, while it preserved the important fact in view, of the indivisibility of the living system, would take into its account the three leading, and in one sense separate, functions performed by the arterial, the nervous, and the glandular organization.

As approaching nearest to this plan, and likewise because it is in most general use in this country, at least as a text book for teachers of medicine, we shall make use in the present article of the nosology of Dr. Cullen, requesting the reader to recollect the unavoidable objections which oppose themselves to all systems and all classifications of morbid affections.

The following are the classes, orders, and genera of Cullen, with the exception of the class locales, which relates to those disorders principally that come under the head of surgery.

TABLE OF CLASSIFICATION.

Class I. Pyrexiæ. A frequent pulse, succeeding to shivering or horror; increased heat; disturbed functions; prostration of strength.

Order I. *Febris.* Pyrexia, independant of local affection as its cause; languor, lassitude, and other signs of debility.

Sect. 1. *Intermittentes.* Fevers arising from the miasma of marshy grounds, with an evident remission, the returning fits being almost always ushered in by horror or trembling. One paroxysm only in the day.

Genera. Tertiana; quartana; quotidiana.

Sect. 2. *Continuæ.* Fevers without intermission, not occasioned by marsh miasma, attended with exacerbations and remissions, though not very preceptible.

Genera. Synocha; typhus; synochus.

Order II. *Phlegmasiæ.* Fever, accompanied by local inflammation or topical pain, lesion, or disturbance of the internal functions; sizy blood.

Genera. Phlogasis ophthalmia; phrenitis; cynanche; pneumonia carditis; peritonitis; gastritis; enteritis; hepatitis; splenitis; nephritis; cystitis; hysteritis; rheumatismus; odontalgia podagra; arthropuosia.

Order III. *Exanthemata.* Contagious diseases, which only affect once during life, commencing with fever, and succeeded by phlogosis or inflammatory cruptions on the skin.

Genera. Erysipelas; pestis; variola; varicella; rubeola miliaria; scarlatina; urticaria; pemphygus; apthæ.

Order IV. *Hemorrhagiæ.* Pyrexia; spontaneous discharge of blood; blood when drawn from a vein of a sizy appearance.

Genera. Epistasis; hemaptisis; hæmarrhois menarrhagia.

Order V. *Profluviæ.* Pyrexia; inordinate discharge, but not of blood.

Genera. Catarrh; dysenteria.

Class II. Neuroses. A lesion of sense and motion, without idiopathic pyrexia or local disorder.

Order I. *Comata.* A diminution of voluntary motion with sleep, or a deprivation of sense.

Genera. Apoplexia; paralysis.

Order II. *Adynamiæ.* Diminished voluntary motion, whether vital or natural.

Genera. Syncope; dyspepsia; hypochondriasis; chlorosis.

Order III. *Spasmi.* Irregular action of the muscular fibre.

Sect. 1. In the animal functions.

Genera. Tetanus; trismus; chorea; raphania; epilepsia.

Sect. 2. In the vital functions.

Genera. Palpitatio; asthma; dyspnæ; pertussis.

Sect. 3. In the natural functions.

Genera. Pyrosis; colica; cholera; diarrhœa; diabetes; hysteria; hydrophobia.

Order VI. *Vesaniæ.* Derangement of judgment, independantly of pyrexia or coma.

Genera. Amextia; melancholia; mania; oncirodynia.

Class III. Cachexiæ. A depraved habit of body, without idiopathic pyrexia orneurosis.

Order I. *Macores.* A wasting of the whole body.

Genera. Tabes; atrophia.

Order II. *Intumescentiæ.* A swelling of the whole or of the greatest part of the body.

Sect. 1. *Adiposiæ.* Fatty swellings.

Genus. Polysarcia.

Sect. 2. *Flatulosæ.* Windy swellings.

Genera. Pneumatosis; tympanites; physometra.

Sect. 3. *Hudropes.* Watery swellings.

Anasarca; hydrocephalus; hydrorachitis; hydrothorax; ascites; hydrometra; hydrocele; physconia.

Order III. *Impetigines.* Cachexies, chiefly deforming the skin and external parts of the body.

Genera. Scrophula; syphilis; scorbutus; elephantiasis; lepra; frainbæsia; trichoma; icterus.

Class I. Order I.—*Febris.*

What is fever? To this question it appears difficult to give a precise and satisfactory reply. It is observed by the author of Zoonomia, that "the term *fever* is given to a collection of morbid symptoms, which are indeed so many distinct diseases that sometimes appear together, and sometimes separate; hence it has no determinate meaning, except it signifies simply a quick pulse, which continues for some hours;" in which sense Dr. Darwin employs the word throughout his ingenious work.

On this head, however, we differ in opinion with the author just mentioned. An increased action of the sanguiferous system shall be induced sometimes by, and at other times independant of, a diseased irritation, without being accompanied with other peculiar feelings, which, not restricting ourselves to the etymological signification of the term *fever*, we purpose regarding as necessary constituents of this, as a distinct malady.

In every proper fever, there is a feeling of depressed power, which essentially differs from actual debility. "A diminution of strength in the animal functions," which constitutes part of Dr. Cullen's definition of the febrile state, is scarcely characteristic of the condition to which we allude. It is a feeling with which every one is more or less familiar, and appears to indicate rather obstructed than exhausted strength. Dr. Rush endeavours to illustrate this necessary constituent of genuine fever as a distinct expression from simple irritation of the blood-vessels on the one hand, and mere debility on the other, by comparing it with the smothered sound which may be supposed to be emitted from a musical instrument, provided a heavy weight were applied to the chords; which ought to be suffered to vibrate freely and without obstruction, in order to produce a full and harmonious sound. An illustration of a similar nature is likewise employed by Dr. Jackson.

Dr. Brown defines fever, "an asthenic disease that disturbs the pulse." In this, however, there is the same want of distinction which we have just complained of in the definition of Dr. Cullen. Asthenic diseases are diseases of deficient excitement; but in fevers we have an interruption rather than diminution of power. The faculties are locked up, not lost.

Of the phenomena of fever. Dr. Cullen very properly selects the more ordinary circumstances that present themselves in the course of an attack of intermittent fever, as an example of what occurs with more or less regularity in every case of genuine febrile disorder.

"The following," he says, "are to be observed in such a paroxysm. The person is affected with languor or sense of debility, a sluggishness in motion, and some uneasiness in exerting it, with frequent yawning and stretching. At the same time the face and extremities become pale, the features shrink, the bulk of every external part is diminished, and the skin over the whole body appears constricted as if cold had been applied to it. At the coming on of these symptoms, some coldness of the extremities, though little taken notice of by the patient, may be perceived by another person. At length the patient himself feels a sensation of cold, commonly first in his back, but then passing over his whole body; and now his skin feels warm to another person. The patient's sense of cold increasing, produces a tremor in all his limbs, with frequent successions or rigors in the trunk of the body. When this sense of cold and its effects have continued for some time, they become less violent, and are alternated with warm flushings. By degrees the cold goes off entirely; and a heat greater than natural prevails and continues over the whole body. With this heat the colour of the skin returns, and a preternatural redness appears especially in the face. Whilst the heat and redness come on, the skin is relaxed and smooth, but for some time continues dry. The features of the face and other parts of the body, recover their usual size, and become even more turgid. When the heat, redness, and turgescence, have increased and continued for some time, a moisture appears on the forehead, and by degrees becomes a sweat, which gradually extends downwards over the whole body. As this sweet continues to flow, the heat of the body abates; the sweat, after continuing for some time, gradually ceases, the body returns to its usual temperature, and most of the functions are restored to their ordinary state.

Species of fevers. The general division of systematics is into continued and intermittent. The very correct description above given answers, as we have stated, to a single paroxysm or fit of fever. It is not however often that the disorder terminates with the decline of the paroxysm. In the course of a certain time it is renewed; and according to the suddenness or tardiness of the paroxysm's recurrence, the fever is called continued, remittent, or intermittent. Sometimes, indeed, the disordered actions recur with such celerity, that the fever appears to be one continuous series; "the remission is inconsiderable, is perhaps without sweat, and the returning parox-

ysm is not marked by the usual symptoms of a cold stage, but chiefly by the exacerbation or aggravation of the hot one." The disease in this last case is considered as a continued fever; in which, however, there is, though not the distinct stages of an intermittent, almost invariably, especially in the earlier periods, a diurnal remission and recurrence of paroxysm. Of intermittent fevers, the paroxysms, such as we have just described, are always finished in less than 24 hours, and most frequently are not extended to nearly this time.

We are then furnished with a natural division of fever into intermittent and continued, which however have many circumstances in common, and often pass into each other; thus, what is termed in the schools a quartan intermittent, formed by an interval of 72 hours from the commencement of one to the commencement of another paroxysm, will in its course become a tertian ague, with only 48 hours of interval: this again shall fall into a quotidian, characterized by an interval of only 24 hours. A quotidian shall pass into the state of a remittent, and this last be converted into a true continued fever.

Besides, however, this leading distinction of fever, from the times of the recurrence of the fits, we have many others arising from the nature of the constitution of the individuals attacked, the prevailing condition of the atmosphere, and other extraneous circumstances, and likewise (what is ascertained however with less exactness) the specific difference of the exciting cause; thus, common fever has sometimes the inflammatory, at others the typhoid, character. Thus are presented the bilious remittent fever of damp and warm climates, the yellow fever of the West India islands, the jail fever of crowded prisons, and the plague in Eastern countries.

On Cullen's genera. It will be perceived that under the appellation of fever we confine ourselves to the consideration of what has been by way of distinction termed simple fever, and perhaps with propriety regarded by Mr. Wilson as "the only general disease," other diseases being either local, or general and local. Thus the sensitive irritated fever of Darwin, which forms principally the phlegmassia of Cullen, is a disorder either symptomatic of, or at least supported by, local irritation.

The genera of Dr. Cullen of continued fever, are,

1. *Synocha.* "Great heat, pulse frequent, strong, and hard; high-coloured urine, the functions of the sensorium not much impaired." Such character. however, does not answer to any case of simple fever; it is the definition of what Dr. Brown calls the sthenic, which is opposed to the true febrile state.

2. *Typhus.* "A contagious disease, the heat not much increased, pulse frequent, small, and weak; urine little changed, sense much impaired, and the strength greatly diminished." This definition approaches nearest to the more usual form of fever in this country. That part of the definition, however, is extremely defective which describes the heat as not much increased.

3. *Synochus.* This is made by Cullen a kind of intermediate disease between synocha and typhus.

Exciting causes of fever. On this subject the most opposite opinions prevail. It is imagined by some, that no case of genuine fever, beyond those ephemeral-irritations which are of daily occurrence, can possibly originate with the previous application, either through the medium of the lungs, or the surface of the body, of a certain something generated in the system of another individual in the course of the same disease. Others infer, from the daily observation of febrile diseases where no communication with the sick can be traced or suspected, that although the febrifacient matter just spoken of be in many, it is not in all instances the cause of fever; that cold, damp, heat, putrid exhalations whether animal or vegetable, insufficient ventilation, the depressing passions, &c. are all, either singly or in conjunction, capable, under some circumstances, not merely of predisposing to, but of actually engendering, proper fever. Lastly, there are some who consider contagion, or the generation in fever of specific febrifacient matter, as totally imaginary; and conceive in instances where fever has spread by communication, that either certain undetected conditions in the air, or the confined effluvia of animal excretions accumulated by want of cleanliness and ventilation, with other circumstances, are causes sufficiently adequate to produce the affection, without supposing the agency of a specific and occult power. "It is from nastiness," says one of the most celebrated of the anticontagionists, "degenerating into infection by chemical changes, that the bodies, clothes, beds, and apartments, of the poor in Great Britain, derive their poisonous, their pestilential charge. By a common putrefactive process, this *septic venom* is formed, and derives none of its qualities from pulsating arteries or glands. Away then with this preposterous phrase, 'from the poison engendered by septic processes.' Let human contagion for the future mean nothing but small-pox, vaccinia, and the kindred forms of morbid secretions." (Dr. Rush.)

Notwithstanding, however, the circumstances here pointed out and rested upon, we conceive the general facts to be in favour of poison engendered, independant of mere putrefaction or filth; and we shall shortly state the grounds upon which our opinion is established, when upon the subject of preventing the spread of fever. That contagion, however, is absolutely requisite to the production of this disorder, in every instance, does not seem an opinion authorized by facts, although it must be admitted that the negative is incapable of proof: for when we refer to its generation from mere filth and sloth, under the circumstances just mentioned from Dr. Rush, it may be replied, that contagion in such cases might have been in some manner conveyed without suspicion, and that the situation of the recipient constituted merely a predisposition to suffer from its application.

A contest has likewise arisen respecting the production of intermittent as well as continued fever. Intermittent fevers are observed to prevail especially in situations the soil of which is marshy: on this account it has been imagined, that they are invariably consequent upon a certain taint or miasma arising from moist ground. "The similarity of the climate, season, soil, in the different countries in which intermittents arise, and the similarity of the disease, though arising in different regions, concur in proving that there is one common cause of these diseases, and that this is the marsh miasma." (Cullen.) Dr. Brown and others have contended, that the noxious influence of cold or of heat, "when the common asthenic noxious powers accompany either," are sufficient to occasion genuine intermittent. It however

appears an established principle, that intermittent fevers are most frequently the offspring of poison arising from marshes or moist ground. That other causes act in conjunction, and augment the predisposition, is likewise an established fact; for the agues of marshy countries occur most abundantly at cold seasons which have succeeded hot ones, and especially amongst those whose diet has been innutritious and unstimulating. It is also beyond dispute that more cold or poor living will induce ague after the habit has been once established.

Proximate cause of fever. On this subject the following errors appear to have misled systematics. 1. A want of distinction between final and proximate cause; between inquiries instituted in order to divine the intentions of nature, and a careful examination of the phenomena of nature as they occur in sequence. 2. The indivisibility of the body, and the universal nature of the disorder, have been too much overlooked. Fever has been considered as an affection of parts rather than of the universal system. 3. An error which appears to result from the conjunction of the two former; that shrinking and coldness of the external surface, which is merely a consequence and concomitant effect resulting from a febrile attack, has been viewed as a cause of the other symptoms which present themselves in the course of the affection.

"The remote causes of fever," says Dr. Cullen, "are certain sedative powers applied to the nervous system, which diminishing the energy of the brain, thereby produce a debility in the whole of the fuctions, and particularly in the action of the extreme vessels; this debility proves an indirect stimulus to the sanguiferous system, whence by the intervention of the cold stage, and spasm connected with it, the action of the heart and larger arteries is increased, and continues till it has had the effect of restoring the energy of the brain, of extending this energy to the extreme vessels, of restoring therefore their action, and thereby especially overcoming the spasm affecting them."

In the historical sketch of the progress of medical theory with which we introduced the present article, it was observed that the spasmodic theory of Hoffman engendered that of Dr. Cullen. In the hands, however, of this last systematist, the doctrine in question appears to have received mutilation rather than amendment: Dr. Cullen added another set of entangled links to the previously entangled chain. The shrinking, coldness, and general inactivity, observed at the commencement of fever fits, and which are the necessary consequences of the sudden quiescence throughout the system, induced by the peculiar action of the noxious powers producing fever, our author considers as one of nature's first steps in obtaining relief and obviating the progress of the disorder.

On this theory we may in the first place remark, that when the progress of a febrile affection is arrested by remedies applied during the first or cold stage, both the torpor of the brain and the shrinking of the surface may be removed without the intervention of the hot fit. Indeed, obviating the recurrence of this constitutes the cure of fever. The succession, then, of the hot fit is not a necessary consequence of the previous cold one, much less is it an agency contrived by nature to remedy this last. The theory is likewise "erroneous, in as far as it enters into the supposed intentions of nature."

Secondly, the action of the heart and larger arteries is not, as is justly observed by Dr. Darwin, occasioned in the mechanical manner of reaction, which the theory we are canvassing supposes. During the continuance of the cold fit, the whole circulation is lessened, or in a manner suspended, the blood is not retreating for safety to the centre, less blood passes through the lungs as well as through the vessels on the surface of the body; the fortress, and not merely the outposts, has received the attack of the enemy. Now, when the hot fit comes on, the marks of irritation, or as Dr. Brown happily terms it, of "counterfeited vigour," by which it is characterized, are merely consequent upon the natural stimuli acting upon accumulated irritability, of irritability accumulated by the previous quiescence of the cold stage, and are not to be attributed to the blood's reacting and flowing back in order to influence and occupy the parts and cavities which it had deserted. This supposed action and reaction cannot indeed take place in that mode and to that extent which our theorists imagine. The human body is a living and not an hydraulic machine. The blood is not dammed up at one part in order to rush with violence into another. To illustrate: When even a part of the body only, as the hand, is immersed in water, or in any other way abruptly exposed to a diminished temperature for a short period, a lessened fibrous or vital action is the immediate consequence, the sensorial power or excitability accumulates in a corresponding ratio, and when the part is now again subjected to the influence of those powers which were previously operating, an irritative and disturbed, in place of regular and healthy, action succeeds; the blood, however, does not flow into the empty vessels like the waters of a river into lateral channels: not more than the same volume of blood, in cases of much weakness not so much, now circulates through parts, the excitability of which has been changed, and an accelerated, but not, properly speaking, increased motion, with febrile heat, is the consequence.

We have perhaps conceded too much to the spasmodic theory of fever, in likening the state of the surface in the cold fit to that produced in consequence of diminished temperature, for in this last the shrinking is directly produced; whereas, in fever, it is occasioned indirectly, or, as we have previously noticed, is merely one of the effects arising from the general interruption of the functions. Fever does not commence by attacking exclusively "the extreme vessels and the capillaries of the surface."

The spasmodic theory of fever then, is not only a substitution of terms for an explanation of facts, but even the phraseology which it employs in order to trace and connect the leading symptoms of the malady, appears to be deduced from defective knowledge of the laws and qualities of life. It is physically, metaphysically, and practically wrong. "Fever fits are not efforts of nature to relieve herself." Darwin.

Before proceeding farther, it may be proper to notice one or two defects, as they appear to us, in the ingenious theory of the author of Zoonomia. In our remarks on nosology, the mistakes which Dr. Darwin had been led into from his untenable division of sensorial power, were

hinted at. These mistakes appear to us to be evident in the learned author's attempts to form a sympathetic theory of the disorders under notice: a theory, which, in our opinion, involves the second error which we have above stated, viz. that of overlooking the indivisibility of the body, or the universal distribution of sensorial power, and regarding fever rather as an affection of parts than of the whole frame. It likewise, by consequence, embraces the erroneous doctrine of ascribing the secondary actions in fevers to the cutaneous torpor. The cold fit of simple fever, says Dr. Darwin, consists of a torpor of the cutaneous capillaries, with their mucous and perspirative glands, which is extended by direct sympathy to the heart and arteries. The torpor, however, of the heart and arteries is coexistent with, and not consequent upon, the inaction of the cutaneous vessels: the sensorial power residing in the former at the time of an attack of fever, must be affected in the same manner as the sensorial power of the latter; and the admission of association, is the introduction of an unnecessary link in the chain of cause. That distant parts sympathize with each other, in a manner which phisiology has not hitherto been able to unfold, as the stomach with the surface of the body for example, is admitted; in the case of fever, however, we wish particularly to insist upon such sympathy as an explanation of symptoms being superfluous: the heart and arteries, the stomach, the surface of the body, the secretory glands, all receive a diminution or sudden interruption of their functions at the same moment of time, and from the same cause: they are simultaneous and not successive effects. Dr. Darwin seems equally unfortunate in referring the hot skin and remaining quiescence of some internal organs, as of the stomach, in the second stage of fever, to reverse sympathy. Sympathy cannot be direct in one instance, and reverse in another: "The laws of association are invariable, or they do not exist."

What then is the cause of fever? It is an abrupt suspension and consequent disruption of all the connected movements of the animal frame by which the balance of excitement is overthrown, "the laws of excitability are changed, and in consequence of which the same agents no longer produce the same effects. Fever differs from debility inasmuch as the latter is a gradual and regular exhaustation, not an abrupt interruption of the powers of life; it differs from strength, as strength consists in a powerful and equable excitement, while fever, however it may "counterfeit vigour," is never attended by the necessary constituent of vigour, regular and orderly display of power.

The primary cold, or as the Latins term it, "horror," is from the quiescence that has been induced; during this state of quiescence, a new and inordinate condition of the excitability is established, and by consequence both the external and internal stimuli excite perturbed in the place of orderly and usual actions: action without power commences; hence morbid heat is generated, diseased associations are formed, and without being in a state of actual weakness, the whole system sinks, oppressed. The plain indications of

Treatment in fever, are therefore to break the morbid associations on which this oppression is established, or obviate the symptoms by which it is continued; to diminish the cold in the cold stage, the heat in the hot stage, and not to await the sanative process of nature, either of dissolving spasm, or of correcting and expelling morbific matter. The various remedies employed for these purposes are, the external and internal use of cold and warm water; refrigerants, sudorifics, opiates, emetics, purgatives: on each of these, we shall introduce a few separate remarks; in the course of which an opportunity will be afforded, of inquiring more minutely into the pathology of the febrile state.

Of cold and tepid affusion, and ablution.—Cold water internally.—Cold air.—The medical reports of Dr. Currie, on the effects of water, cold and warm, in the treatment of fever, are introduced in the following manner:

Narrative of Dr. Wright.

"In the London Medical Journal for the year 1786 Dr. William Wright, formerly of the island of Jamaica, gave an account of the successful treatment of some cases of fever, by the ablution of the patient with cold water.

"On the 1st of August, 1777," says Dr. Wright, "I embarked in a ship bound to Liverpool, and sailed the same evening from Montego-bay. The master told me he had several sailors on the same day we took our departure, one of whom had been at sick quarters on shore, and was now but in a convalescent state. On the 23d of August, we were in the latitude of Bermudas, and had had a very heavy gale of wind for three days, when the above-mentioned man relapsed, and had a fever with symptoms of the greatest malignity. I attended this person often, but could not prevail on him to be removed from a dark and confined situation to a more airy and convenient part of the ship; and as he refused medicine and even food, he died on the eighth day of his illness.

"By my attention to the sick man, I caught the contagion, and began to be indisposed on the 5th of September; and the following is a narrative of my case, extracted from notes daily marked down: I had been many years in Jamaica, but except being somewhat relaxed by the climate and fatigue of business, I ailed nothing when I embarked. This circumstance, however, might perhaps dispose me more readily to receive the infection.

"Sept. 5th, 6th, 7th: Small rigours now and then; a preternatural heat of the skin; a dull pain in the forehead; the pulse small and quick: a loss of appetite, bu no sickness at the stomach; the tongue white and slimy; little or no thirst; the belly regular; the urine pale and rather scanty; in the night restless with starting and delirium.

"Sept. 8th. Every symptom aggravated; with pains in the loins and lower limbs, and stiffness in the thighs and hams.

"I took a gentle vomit on the second day of this illness, and next morning a decoction of tamarinds; at bedtime an opiate joined with antimonial wine; but this did not procure sleep or open the pores of the skin. No inflammatory symptoms being present, a drachm of Peruvian bark was taken every hour for six hours successively, and now and then a glass of port-wine, but with no apparent benefit. When upon deck my pains were greatly mitigated, and the colder the air the better. This circumstance, and the failure of every means I had tried,

encouraged me to put in practice on myself, what I had often wished to try on others, in fevers similar to my own.

"Sept. 9th. Having given the necessary directions, about three o'clock in the afternoon I slipt off all my clothes, and threw a sea-cloak loosely about me till I got upon deck, when the cloak also was laid aside: three buckets of salt water were then thrown at once upon me; the shock was great, but I felt immediate relief. The head-ache and other pains instantly abated, and a fine glow and diaphoresis succeeded; towards evening, however, the same febrile symptoms threatened a return, and I had again recourse to the same method as before, with the same good effect. I now took food with an appetite, and for the first time had a sound night's rest.

"Sept. 10. No fever, but a little uneasiness on the hams and thighs; used the cold bath twice.

"Sept. 11. Every symptom vanished; but to prevent a relapse I used the cold bath twice. Mr. Thomas Kirk, a young gentleman, passenger in the same ship, fell sick of a fever on the 9th day of August; his symptoms were nearly similar to mine, and baving taken some medicines without experiencing relief, he was desirous of trying the cold bath; with my approbation he did on the 11th and 12th of September, and by this method was happily restored to health. He lives at this time (Jan. 1786) near Liverpool."

We have thus presented our readers with this important narration of Dr. Wright, both as it furnishes a history of fever, as it details the mode in which the cold affusions should be employed, and as it was confessedly the means of introducing this most valuable remedy into general practice. We shall now add from Dr. Currie the more particular rules which ought to govern the use of the affusion or aspersion of cold water in fevers, and then make one or two observations on the nature of its operations.

"The safest and most advantageous time," says Dr. Currie, "for using the cold water is, when the exacerbation is at its height, or immediately after its declination has begun; and this has led me almost always to direct it to be employed from six to nine in the evening; but it may be safely used at any time of the day, *when there is no sense of chilliness present, when the heat of the surface is steadily above what is natural, and when there is no general or profuse perspiration.*—These particulars are of the utmost importance: for, 1st. If the affusion be used during the cold stage, the respiration is nearly suspended; the pulse becomes fluttering, feeble, and of incalculable frequency; the surface and the extremities become doubly cold and shrivelled, and the patient seems to struggle with the pangs of instant dissolution. I have no doubt, from what I have observed, that in such circumstances the repeated affusions of a few buckets of cold water would extinguish life. This remedy should therefore never be used when any considerable sense of chilliness is present, even though the thermometer applied to the trunk of the body, should indicate a degree of heat greater than usual.

"2nd. Neither ought it to be used, when the heat measured by the thermometer is less than, or even only equal to, the natural heat, though the patient should feel no degree of chilliness. This is sometimes the case towards the last stages of fever, when the powers of life are two weak to sustain so powerful a stimulus.

"3d. It is also necessary to abstain from the use of this remedy under profuse sensible perspiration, and this caution is more important in proportion to the continuance of this perspiration."

"Under these restrictions," our author adds, "the cold affusion may be used at any period of fever; but its effects are more salutary in proportion as it is used early. When employed in the advanced stages of fever, where the heat is reduced and the debility great, some cordial should be given immediately after, and the best is warm wine."

Observations. Cold water as a remedy for fever, may be conceived to operate upon a twofold principle. In the earlier stages, and before the vital power is too much harassed and oppressed to endure a violent shock, the copious and sudden affusion of cold water all over the naked body, appears to effect its beneficial purposes in part by the abruptness of its agency; it in a manner severs the chain of diseased associations, and restores the healthy and orderly movements of the frame. This operation is not, as has been suggested, mechanical: it is in some measure similar to that produced by the operation of an emetic, to which it is in every respect greatly preferable, or to sudden mental agitation. In the language of the schools, it cuts short fever.

When, however, the diseased associations are more firmly established, and the vital power greatly oppressed by the disorder's continuance, although the surface of the body retains its morbid heat, the water is to be applied, not in the way of sudden affusion, but by washing with a spunge, and this under the restrictions enjoined by Dr. Currie, or we may safely say, while it is found genial to the patient's feelings, ought to be resorted to in every case of simple fever. The action of the water at this time is somewhat different fron that in the previous period, or under different circumstances of the disorder. It proves a direct stimulus. But how, it has been urged, can the negative of a power prove stimulative? "Darkness might as well be called a stimulus to the eye, or hunger a stimulus to the stomach, as cold to our sense which perceives heat." Darwin. To this it has been replied by Dr. Currie, and before him by Dr. Beddoes, that the objection is founded upon a disregard of the sentient principle: "Cold," says the latter author, "may very often be so applied as, by removing the very disagreeable sense of heat, that attends some diseases, to produce an effect equivalent to stimulation. It is, I believe, exactly in this way, that bathing the body with cold water proves serviceable in low fevers."

From the urgency, however, of the debility, or from the prejudices of the patient or his friends, in some periods of fever, even the application of cold water in the way of ablution may be regarded as too severe. In this case tepid ablution has been made to supply its place, and often with propriety and success; it is, however, particularly deserving of remark, that unless this last be used with precaution, the object of the practitioner in its choice is defeated, as the evaporation from the surface is more copious from the tepid affusion; and this is one of the most powerful, indeed, strictly speaking, the only means of abstracting heat. The term tepid is applied by Dr.

Currie to water, from 87° to 97° of Fahrenheit; from 87° to 75° the water is dominated cool. Cold water may be given internally, and with the utmost freedom, in the hot stage of the febrile paroxysm. Its use, however, requires to be carefully regulated by the same restrictions as in the external application; it must never be given unless the heat of the surface be steadily above the natural standard. Draughts of cold water have been known, when properly administered, to procure a sudden solution of the disease.

Cold air. The extraordinary melioration in the modern practice of medicine, as it relates to the treatment of fever and febrile diseases, is not confined to the copious use of affusion and ablution. The terrors of our predecessors, in relation likewise to cold air, are fast departing; and the importance of its free admission in the apartments of the febrile sufferer especially, comes to be generally acknowledged and applied. It has been stated by a physician, above all praise for fidelity of observation and justness of remark, that the corrupted air of sick rooms, from neglect of ventilation, has been much more fatal even among the higher classes of society, than the virulence of the disease itself: "Vereor ne quidam ægroti non tam morbo suo perierint, quam halitibus putribus, quos discuti vetuit præpostera amicorum cura." Heberden.

The utility of cold air in fever is referrible to two principles: 1st. That of immediately lowering the heat of the surface, and thus taking off the oppression occasioned by such heat: and 2ndly, from affording a larger quantity of oxygen at each inspiration. The first of these principles is sufficiently evident, and does not require any further illustration: if cold ablution prove beneficial chiefly by virtue of diminishing the temperature of the body, it necessarily follows that coldness in the circumambient atmosphere must be attended with precisely similar effects: but on the purity, as connected with diminished temperature of the atmosphere, it may not be improper to embrace the present opportunity of offering one or two remarks. A given bulk of air at an inferior temperature, contains more of the oxygenous principle than the same quantity at a superior degree of heat; hence the greater refreshment which is experienced from the inhalation of a cold and dense, over that of a warm and rarefied atmosphere; hence, in part, the more vigorous digestion and keen appetite of a healthy individual during the winter, than the summer months; and finally, by the relief a febrile patient experiences from the inspiration of such air, it is rendered evident, both that the heat of fever originates, and is kept up, independently of those organs which modern chemistry and physiology have supposed to be the sole organs for the supply of heat to the living system. From this fact Dr. Reid infers, and we think with justice, that the constant equality of animal temperature in a condition of health, has more dependance upon living actions in general than upon the chemical evolution of caloric in the lungs, according to the ingenious theory first suggested by Dr. Crawford, but since materially modified. See Physiology.

But the frigorific virtue of a more oxygenous atmosphere, when received into the lungs of a febrile invalid, is a further proof, that however violent the reaction, as it has been erroneously called, such reaction is, in every case of genuine fever, far from being an evidence of actual increase of power. Whatever theory we adopt respecting the precise mode in which pure air influences the animal economy, an uniformity of opinion must prevail, that it is, in the strictest sense of the word, an exciting agent. Now as far as it operates beneficially in fever, it reduces the inordinate heat; that power then which actually and properly exists, by this very agency moderates the turbulent action, and by consequence reduces the prevailing morbid heat. The admission of cold air requires likewise to be restricted to the hot stage, and to be limited by the patient's feelings; a current of cold air passing rapidly over the body while in a state of perspiration, may be productive of fatal consequences.

Of refrigerants in fever. Besides, however, the employment of cold water, and the free admission of a cool and pure atmosphere, other agents have been had recourse to, and with considerable effect, in order to abate the inordinate heat of fever. From possessing the faculty of cooling the system, certain medicines have been distinguished by the term refrigerants: refrigerants are principally chosen from the vegetable acids, and the different neutral salts; and so evident is their power in reducing animal temperature, that they have properly been made to constitute a considerable part of regimen in fever. Indeed nitre, and other neutral salts, with the vegetable acids, have been received into some systems of classification, under the distinct head of febrifuge medicines. The modus operandi of refrigerants has not perhaps hitherto received explanation; the substances of which they are composed are for the most part those which contain oxygen in a concentrated, and, at the same time, loose state of combination; from this circumstance, their action has been ingeniously but not perhaps satisfactorily accounted for. "It has been sufficiently established," says a modern writer, "that the consumption of oxygen in the lungs is materially influenced by the nature of the ingesta received into the stomach; that it is increased by animal food and spirituous liquors, and, in general, by whatever substances contain a comparatively small quantity of oxygen in their composition. But the superior temperature of animals is derived from the consumption of oxygen gas by respiration; an increase of that consumption must necessarily, therefore, occasion a greater evolution of caloric in the system, and of course an increase of temperature, while a diminution in the consumption of oxygen must have an opposite effect. If, therefore, when the temperature of the body is morbidly increased, substances be introduced into the stomach, containing a large proportion of oxygen, especially in a state of loose combination, and capable of being assimilated by the digestive powers, the nutritious matter received into the blood must contain a larger proportion of oxygen than usual; less of that principle will be consumed in the lungs, by which means less caloric being evolved, the temperature of the body must be reduced; and this operating as a reduction of stimulus, will diminish the number and force of the contractions of the heart." Murray's Materia Medica.

This reasoning is perhaps more specious than just. In the first place, the remarks which we have above introduced on the actual diminution of febrile heat from in-

haling an oxygenous atmosphere, seem to oppose the theory of refrigeration, from "less of the oxygenous principle being consumed in the lungs." Secondly, it may be noticed that the effects of these medicines are too speedy and direct to admit of the supposition of this intermediate kind of agency; and thirdly, although the refrigerantia are for the most part, they are not universally, substances which contain this superabundance of the oxygenous principle. The saline draught, for example, appears to moderate febrile heat, principally by reason of the carbonic acid gas that it contains.

Chemical reasoning has recently been extensively applied to the developement of the mode in general in which the functions of the stomach and lungs are connected, and as this inquiry is closely related both to the theory of febrile heat, and the dietetical as well as the medicinal management of the febrile invalid, it may not be improper to detain the reader by one or two further reflections on this very interesting point of discussion. It is an axiom of Hippocrates, that animal food should not be given in fever; an axiom which was no doubt founded upon observation of its general irritating and disordering tendency. Modern physiology, however, has not rested content with a knowledge of the fact, but has endeavoured to divine its immediate cause. That digestion of the food is, cæteris paribus, in proportion to the oxygenation of the blood; or to avoid an expression involving theory, to the purity of air and freedom of inspiration, which an individual enjoys, is without question; and it is further evident from daily observation, that the facility of assimilating animal food, in particular, is increased by air, exercise, and whatever promotes an uninterrupted circulation through the pulmonary organs. Hence it is said, we are furnished with an explanation why animal diet is uncongenial to the patient in fever. The pulmonary circulation is impeded by febrile oppression, less oxygen is received from the atmosphere, and the power of assimilating materials which contain the hydrogenous and azotic principles in abundance is consequently weakened, or, as we have heard it expressed still more chemically, less fuel or combustible matter is required, on account of there being less power of consuming such fuel, or of maintaining combustion.

Perhaps the peculiarity or distinct nature of living action, has not been sufficiently attended to by modern physiologists of the chemical school. That hypothesis, the outline of which we have just delineated, appears at first sight perspicuous and unobjectionable, but when pursued more in detail, facts present themselves which are in some measure at variance with its fundamental principles.

Animal food may, perhaps, prove less congenial to the patient in fever, than under circumstances of debility without febrile disturbance, on account of the direct irritation it communicates to the fibre, independantly of its chemical properties; the difference between animal and vegetable diet in this particular, is abundantly obvious. But it may further be urged, that several materials taken into the stomach during the burning heat of fever, appear to be productive of nearly similar effects, in their immediate operation, with a diet of animal food; of this we have an instance in opium. Opium, which when duly administered is congenial and salutary, when given while the skin is dry, and there is no disposition to perspiration, proves irritating and hurtful; it still further impedes the weakened digestive organs, augments the tendency to costiveness, and increases febrile heat. These properties it surely does not possess by virtue of the quantity of hydrogen or azote that it contains.

Of Sudorifics.

We now proceed to consider the agency of sudorifics as febrifuge remedies. Moisture on the surface of the body may be procured by medicines which appear to have a direct power over the cutaneous vessels, or by those whose action seems to be directed primarily to the stomach. These last are principally of the saline class, which are by far the most suitable in the febrile state.

The physiology of perspiration, and the principles by which it operates as a cooling process, are, notwithstanding the recent discoveries in chemistry, and their application to this interesting subject, still involved in much obscurity.

The ancients imagined sweat to be not merely an excrementitious product, but the vehicle of conveying that morbific matter out of the body which had been the occasion of disease. This opinion does not, in the present state of science, require to be confuted. The questions of most interest, respecting the phenomena and causes of perspiration, are, in what relation does it stand to the respiratory function; and is that moisture on the surface of the skin which closes a febrile paroxysm, to be regarded as a cause or consequence of the disorder's declination?

"That an animal," says Dr. Currie, "possesses to a certain extent the faculty of rendering sensible heat latent, or, to speak more philosophically, of reducing caloric from a free to a combined state, in cases in which the stimulus of heat might otherwise overpower the living energy, there is reason to believe, from a variety of experiments and observations, and that this is in part performed by perspiration from the surface can scarcely admit of a doubt. The process of perspiration, which is continually going on from the surface of the body, is in this point of view the converse of respiration; as in respiration a gas is constantly converted into a solid or fluid, and thus heat evolved, so in perspiration a fluid is constantly converted into a vapour, and thus heat is absorbed. A vessel filled with water and exposed to the atmosphere, cannot be raised above 220° of Fahrenheit by any quantity of fuel, because heat is applied from below, evaporation carries it off from the surface; in like manner we may suppose the heat of the living body to be kept uniform, by the evaporation from its surface increasing or diminishing, according to the quantity of heat extricated from the system, or received from the surrounding medium."

These speculations are beautiful and highly ingenious. It however admits of question, whether Dr. Currie, in applying them to the subject of febrile heat, may not have given too much weight to the analogy of absorption of caloric in inanimate matter, as explanatory of the cooling process in the living body; and whether sensible perspiration, produced by medicine or otherwise, may not be consequent upon, rather than prior to, the diminution of febrile heat? If, for example, a large quan-

tity of water be swallowed in the height of a febrile paroxysm, and be directly succeeded by general diaphoresis, or sweat, with relief from the burning sensations of fever, although it be natural to attribute such relief to the sweat that is produced, this last may be subsequent to that altered condition of the fibre by which the evolution of caloric is diminished. Such an opinion has been ingeniously argued by Dr. Reid; and if the following observations of Dr. Darwin are just, they appear to place the matter beyond dispute. "The perspirable matter," says this last author, "is secreted in as great quantity during the hot fit of fever, as towards the end of it, when the sweat is seen upon the skin. But during the hot fit, the cutaneous absorbents act also with increased energy, and the exhalation is likewise increased by the greater heat of the skin; and hence it does not appear in drops upon the surface; but is in part reabsorbed and in part dissipated in the atmosphere. But as the mouths of the cutaneous absorbents are exposed to the cool air or bed-clothes; while those of the capillary glands, which secrete the perspirable matter, are exposed to the warmth of the circulating blood; the former, as soon as the fever fit begins to decline, lose their increased action first; and hence the absorption of sweat is diminished, whilst the increased secretion of it continues for some hours afterwards, which occasions it to stand in drops upon the skin. As the skin becomes cooler, the evaporation of the perspirable matter becomes less as well as the absorption of it. And hence the dissipation of aqueous fluids from the body, and consequent thirst, are perhaps greater during the hot fit than during the subsequent sweat. For the sweats do not occur, according to Dr. Alexander's experiments, till the skin is cooled from 112 to 108 degrees of heat; that is, till the paroxysm begins to decline. From this it appears that the sweats are not critical to the hot fit, any more than the hot fit can be called critical to the cold one, but simply that they are the natural consequences of the decline of the hot fit. And from hence," continues our author, "it may be concluded, that a fever fit is not an effort of nature to restore health, but a necessary consequence of the previous torpor; and that the causes of fever would be less detrimental, if the fever itself could be prevented from existing, as appears in the cool treatment of the small pox."

Of Purgatives and Emetics.

Nothing, perhaps, is of greater moment in almost every stage and every kind of fever, than to preserve the whole of the alimentary canal free from accumulations of colluvies, &c. From a deficient attention to this principle, the medical practitioner is in many instances foiled in the treatment of this, and indeed in a variety of other diseases. Viscidities and impurities in the stomach and bowels, are often both effect and cause of the persistance of the febrile state; for as the powers of assimilation are weakened by the induction of fever, so the consequent accumulations of foreign matter in the alimentary and intestinal canal, themselves prove direct sources of irritation and disorder. In the primary stages of fever, an emetic has been known abruptly to arrest its progress, and the same purpose is sometimes accomplished, especially in ephemeral affections of the febrile kind, by the employment of a brisk purgative. In the more advanced periods however of the disorder, the object of the physician ought to be rather that of keeping the bowels gently open, and this is best effected by saline in place of drastic purgatives; the former of which principally operate by exciting the exhalants on the internal surface of the intestines to pour out their contents, the latter by stimulating in a forcible manner the intestinal fibre.

It is a fact worthy particular notice in the treatment of fevers especially, that where due attention is given to ensure regular evacuations from the bowels, those stimuli, the copious use of which is often necessary to support the sinking powers in the last stages of the disease, are more freely admissible and abundantly more efficacious: this is indeed an important principle in the treatment of diseases generally; and it is perhaps chiefly by virtue of preserving the excitability in an orderly and due condition for the agency of other stimuli, that purgatives, like sudorifics, form so useful, and indeed the former, almost an indispensable, part of the remedial process in the greater number of aliments. In intermittent fevers it is generally necessary to evacuate the bowels by more stimulant cathartics, more especially when the cure of these fevers is conducted by the Peruvian bark.

Having thus discussed the nature, causes, and treatment of fever, it may be proper to present the reader with a recapitulatory view of the remedies which are required in the different forms of this affection: as a preliminary, however, to such recapitulation, we shall make one or two remarks on the more unfavourable symptoms with which fever is sometimes attended, and on the periods in which the disorder displays a greater or less disposition to terminate.

The unfavourable signs are, in the first place, an abrupt alteration of type. If during fever, indicating in its primary stages no particular severity of disease, a rapid change take place in the feelings and expressions of the invalid; if upon the more ordinary symptoms, suddenly and unexpectedly supervene delirium, prostration of strength, an observable change in the countenance, accompanied by irregular and partial alterations of heat and cold, without the intervention of the perspiring state, the patient's life is in considerable danger. The above changes are often indeed preludes to a speedy death.

Weakness, quickness, and irregularity of pulse, delirium, tendency to fainting when in an erect posture, prostration of strength, partial and irregular sweats, difficult respiration and deglutition, starting of the tendons, unusual fœtor in the excretions, great foulness of the tongue and fauces, are all evidences of a fatal tendency in the complaint; in general likewise it may be observed, that in cases where marks of great nervous irritation attend the onset of a fever, even though the disorder may not assume what has erroneously been termed the putrid type, much danger is to be apprehended. Indeed, the management of fever is not seldom rendered more difficult, and the indications of treatment less decided, from the absence of such type. Genuine nervous fevers are often the most obstinate and malignant.

In fevers of this kind, indeed, the heat is often so partial and irregular as not to admit of the cold affusion. Dr. Currie in his Medical Reports, describes a fever in

which this remedy was tried without success. This fever, says Dr. Currie, does not appear to originate in contagion, or to be propagated by contagion.

Calculations respecting critical days have been in some measure forced and systematic. It is worthy however of remark, that continued fevers as well as intermittent, in the successive stages of their course, are disposed to assume progressively the quotidian, tertian, and quartan aspect.

Thus, if the fever has lasted more than a week, the ninth and eleventh days from its first attack are those on which we may anticipate its declination; after the second week the seventeenth and twentieth are the more usual days of termination. These, however, are by no means unexceptionable rules.

RECAPITULATION OF THE TREATMENT OF FEVER.

Treatment of continued fever during the first three or four days. Cold affusion. Water to be impregnated with salt, its application to be confined to the hot stages of the paroxysm. Large draughts of cold water taken under the same limitation. Cold and pure air. Emetics. Purgatives. Antimonial and saline sudorifics.

After the fifth or sixth day. Cold and tepid ablution. Water employed to be impregnated with salt or mixed with vinegar. In the urgency of debility, coldness, or delirium, pediluvium or the warm bath. Bowels to be kept gently but constantly open, by saline or mild purgatives and subacid drinks. While the skin is preserved moist by diaphoretics, give opiates and wine; these last are almost invariably improper when the skin is dry and hot, and the bowels costive. For head-ache and other nervous affections, blisters, æther, camphor. In the last stages, when critical sweats break out, and the powers of life appear to be shrinking from the contest, repeated glasses of port wine with tincture of opium in large quantities. During the whole couse of the disease, the apartment to be diligently preserved cool, clean, constantly ventilated, and free from all individuals but those who are necessary attendants on the sick.

Treatment of intermittent fever. Cold affusion immediately upon the full accession of the hot fit. Warm bath, warm spiced wine, during the cold stage of the paroxysm. Tincture of opium, either previous to the accession of the cold; or towards the decline of the hot fit. Emetics, immediately preceding the accession of the paroxysm. Calomel purges before the administration of tonics; arsenic, zinc, Peruvian bark, quassia, and if any enlargement of one of the viscera (ague cake) appear, steel. Hope: upon the excitation of hope the power of charms altogether depends; these sometimes succeed in ague, when other remedies are counteracted by the violence of the complaint.

Although he have judged it expedient to enumerate the different medicines which in the event of fever's protraction may be requisite, it is proper to observe that the progress of the complaint may for the most part be abruptly arrested, and the necessity of other means of cure consequently superseded, by an early and judicious employment of the cold affusion. If the application of the water in the mode described in the narrative of Dr. Wright be objected to, a shower bath may be employed, or, what is an excellent and convenient substitute for the latter, a common gardener's watering-pot; the patient is to be taken out of his bed, if convenient, conducted or carried into an adjoining apartment, and the water poured from this instrument as hastily as it will admit of over his naked body; the skin is then to be quickly and effectually dried with towels, and the invalid reconducted to his bed; this course is to be repeated with the full recurrence of the hot paroxysm, even should this be on the same day, and continued, if requisite, on the following days, until the disorder's decline; or, in the pointed language of a modern writer, until "the fever be washed away." (Reid's Medical Reports, Monthly Magazine.)

Fever Houses, &c.

The rapid and extended diffusion of fever through families and districts might be deemed sufficient evidence in favour of matter engendered by febrile action, having the power to produce a similar disorder in another individual. The fact, however, appears to have been placced beyond doubt by the unfortunate result of several experiments made with sceptical temerity in order to prove the negative of this assumption.

While the writer of the present article was pursuing his studies in the Edinburgh university, several anticontagionists, as these gentlemen were denominated, freely exposed themselves within what they regarded the imaginary sphere of contagion, in the wards of the infirmary of that city; many in consequence became infected with fever, and in some instance the disorder had a fatal termination. In these instances the production of the disease could not be referred to want of cleanliness, or to any peculiar condition of the atmosphere; for the fever did not extend to those gentlemen attending the hospital, who were fortunate enough to remain satisfied with the previous evidence in favour of contagion.

But with a knowledge of the evil, we have at length acquired a knowledge of its antidote; and it has been demonstrated by experiments upon a most extensive scale, that, whether the matter producing fever be introduced into the system by the lungs, the surface of the body, or the stomach, its power to infect extends but an exceedingly small distance—three feet at furthest—from the patient in whom it is generated, "when he is confined where the air has free entrance and egress." This fact, it has been well observed, "cannot be corroborated by too great a variety of testimony, nor repeated too often, until it shall be familiar not only to the most unlearned of the profession, but well known to the community at large." (Dr. Bateman.)

Its application with that of another fact immediately to be mentioned, has already gone a considerable way towards the actual extermination of febrile contagion.

This second fact is, that although infectious matter be rendered almost immediately inert by exposure to the air, it is capable of being rendered concentrated, and even transported to an unlimited distance, when made to come in contact with any material, even "a rag or a bit of lint," if such material be excluded from the air. From these, one should expect unquestionable premises, separate receptacles, apartments, and houses, have been exclusively devoted to the admission of the sick in fever, and, as we have just observed, with the most eviden

and extended benefit, particularly to the inferior classes of the community.

The example of fever institutions was set to the metropolis by the very active and laudable exertions of provincial physicians. In Chester, Manchester, Liverpool, Dublin, Cork, and other large towns in the British isles, the plan of thus separating the infectious fevers from other diseases, had already been adopted, and at length an establishment of this kind was founded in Gray's-inn-lane, in London, and with the happiest effects. Among the internal regulations of these houses, the following are the most important;—they have been adopted in the fever wards of common hospitals, and apply in a general manner to private practice.

Every patient when admitted into the house, is to change his infectious for clean linen; the face and hands are to be washed clean with warm water, and the lower extremities fomented. "The effect which this salutary change has upon the patient before any medicine is given, is often more beneficial than those which all the febrifuge drugs in the world could bestow." All discharges are to be speedily removed. The floors of the sick room are to be washed twice a week, and near the beds every day. The cloths which the patient brings with him are to be carefully purified by washing the linen, and exposure for a length of time of the other habiliments to pure air.

Blankets and other bed-clothes are to be exposed to the open and fresh air before they are used by another patient. Several windows of the apartment to be constantly opened in the day, unless the weather is very cold and wet; and some of them should not be shut in the night, if the patients are numerous, and the weather moderate.

By a due enforcement of these regulations, the necessity in general may be obviated of employing the acid fumigations recommended by Morveau, Carmichael Smith, and others, which have been ingeniously, and we think justly, imagined to operate upon the same principles with atmospheric or pure air, viz. by oxidating, and thus destroying the virulence of the contagious effluvia.

By cleanliness then, and procuring a free circulation of air, by guarding against the lodgment of contagious matter, and by keeping as much as possible from actual contact with the sick in fever, every cause is obviated from which infection can be communicated. The individual who resides in the house adjoining to a fever institution is equally out of the sphere of contagious influence with one at fifty miles distance; nay, in the contiguous apartment, and even in the sick room itself, the immunity is precisely the same: such are the preventive as well as the sanative effects of cleanliness and ventilation, which, whether in sickness or in health, cannot be too highly appreciated, or too extensively adopted.

Order II.—*Phlegmasiæ*, Inflammations.

When any part of the body has an unusual heat and redness, with pain and swelling, it is said to be inflamed. To constitute this state of a part, an inordinate action and dilation of vessels have generally been esteemed sufficient. Such opinion, however, has been questioned by the author of Zoonomia. "Inflammation," says Dr. Darwin, "is uniformly attended with the production or secretion of new fibres, constituting new vessels; this, therefore, may be esteemed its essential character, or criterion of its existence. The extension of the old vessels seems rather a consequence than a cause of the germination or pullulation of these new ones; for the old vessels may be enlarged and excited with unusual energy, without any production of new ones, as in the blush of shame or of anger." On the contrary, however, we are disposed to regard the formation of new vessels, which does not perhaps take place in every case even of genuine inflammation, to be subsequent to, and not the occasion of, capillary dilatation. The case which Dr. Darwin puts in opposition to this theory is not in point. It is permanent and forcible, not transcient and slight, extension of blood vessels, which constitutes the inflamed state. The eye may be exposed to a vivid light, its vessels consequently act with more than ordinary excitement, and this to a certain extent without actual inflammation; but if such excitation be extended beyond a certain point, the small vessels of the organ shall be deprived of their proper resistance, and thus shall not merely transmit a more than due quantity of blood, but such blood shall in a manner become congested in their vessels, and shall cause pain, unusual redness, heat, and tumour. This induced weakness of the capillaries, ought then, perhaps, according to the opinion of some modern physiologists, to be regarded as the proximate cause of inflammation; the too great or too little excitement on which it may have depended the remote cause; and the increased action of the larger vessels of the part, the proximate effect. The augmented action, if considerable, is accompanied by an irritation of the whole system; such irritation constitutes the "sensitive irritated fever" of Dr. Darwin, which is distinguished from simple, or what we have considered genuine fever, by its being a sequent of local affection.

Sthenic and asthenic inflammation. The disturbance of the system does not correspond more with the magnitude of the local disorder, than with the constitutional character of the individual affected. Of two persons that are the subjects of inflammation, as of the mucous membrane of the nostrils, constituting inflammatory catarrh, or a cold; of the pulmonary vessels, occasioning inflammation of the lungs; or of the joints, forming rheumatism; one shall previously have possessed much constitutional vigour, the other shall have been languid and feeble—the former will have a sthenic, the latter asthenic disease. This distinction in practice will be found of immeasurable importance. It was first distinctly pointed out by Dr. Brown. We believe, however, that this author was mistaken in the mode in which the inflammation of a part, and the disorder of the system, are connected; for the purpose of confirming his favourite tenet of sthenic and asthenic disorder, he laboured to prove that the systematic in many cases of inflammation actually preceded the local disease—this is not the case. Even in the most violent forms of pneumonia, the disorder of the lungs precedes that of the system: and indeed sthenic disorder, independantly of local irritation, is in some measure a contradiction in terms. High excitement, to whatever extent it may be carried, while there is no irregularity or want of balance in any of the corporeal or mental functions, and no affection of a part cannot be properly regarded

as a disease, however it may predispose to the diseased state.

Termination of inflammation. Inflammation is said to be resolved when the natural state and action of parts are renewed without disorganization. If, however, the inflammation has existed for any time, or has been violent, an unnatural secretion takes place from the vessels inflamed, which is called pus; this when collected or confirmed, constitutes abscess, and when the inflammation ends in this manner, it is said to terminate by suppuration. In cases of much weakness, constitutional or induced, the vascular action in the part shall cease altogether, its excitability be irrecoverably exhausted, and what in scholastic language is termed gangrene be the consequence, which extending, shall form spacelus, or mortification. Resolution, suppuration, gangrene, are therefore the usual modes in which inflammation terminates. There are others, however, which are peculiar to certain parts; thus, an inflammation of the lungs often ends fatally by a copious effusion of a watery matter into the cellular texture of these organs; thus, an inflammation of a gland shall end in schirrus, or hardness of the parts, depending perhaps upon the deposition of matter which remains unabsorbed.

Species of inflammation. This disorder is systematically divided into two leading species—phlegmonous and erythematic. The first is defined by Dr. Cullen, "an inflammation of a bright-red colour, with a circumscribed pointed tumour, and tending towards suppuration." The erythema has a less vivid colour, with scarcely any tumour, spreading irregularly, burning rather than throbbing pain, and terminating in vesicles.

These species are principally established by the difference of part upon which the inflammation may happen to fall. Thus if the disorder be seated superficially, or in any internal part where there is an uninterrupted expansive or cellular texture, it will be erythematic or spreading; if it be more deeply lodged among muscular substance, it will be for the most part phlegmonic.

Indications of the disorder's decline. It scarcely requires to be observed, that a cessation of pain, a reduction of tumor, a loss of redness and heat, a diminution of the systematic disturbance, are all evidences that the inflammation is about to terminate. If, however, it be suffered to run on into the stage of suppuration, the indications of this state are, the pulse becoming fuller and softer, the patient being attacked with shiverings, and a pulsatory feel in the affected part. Again, the tendency to gangrene is denoted by the tumour losing of its redness, and assuming a darker hue; by the sudden cessation of pain; sometimes by blisters arising near or upon the tumour; and, lastly, if the local disorder have been considerable, by a rapid declension of the pulse, and powers of life.

Treatment. The indications of cure are to be deduced from the sthenic or asthenic disposition of the disease, and from the peculiar nature of the part or organ injured.

Before the time of Dr. Brown, action, at least inflammatory action, was too indiscriminately viewed as an evidence of power; the inference from this highly erroneous doctrine was, that inflammation almost invariably required for its cure a debilitating and evacuating plan of treatment. Nothing can be more inconsistent with the laws of the animal economy.

"It had been," says the author of the Elementa Medicinæ, "a prevailing opinion that the fits of the gout could not be constituted by debility, because inflammation accompanies them. This question he subjected to the test of experiment. He invited some friends to dinner; and by taking stimulants in their presence, recovered the most perfect use of that foot with which, before dinner, he could not touch the floor for pain. By this he saw, that not only the gout itself, but the inflammation accompanying it, was asthenic, that is, depending upon debility. Such he found likewise to be the nature of the inflammations in the gangrenous sore throat, in chronic rheumatism, &c. &c." The application of this principle in the practice of medicine has proved of incalculable importance. In conducting the cure, then, of inflammation, the physician is to be guided not so much by the extent and degree of the local injury, as by the nature of what Brown calls the prevailing diathesis; if inflammation be attended by a full, hard, and vigorous pulse, with other expressions of power, a debilitating plan of treatment is to be adopted; blood is to be drawn from the arm, saline purgatives are to be administered; cold, under the limitations immediately to be mentioned, is to be applied, and the exciting powers as much as possible withdrawn. If, on the contrary, an equal degree of local affection shall be accompanied with feeble, although quick, pulse, and the remaining symptoms of debility, an opposite plan, under certain regulations and exceptions, is to be pursued; stimulants are to be thrown in, and the inflammation cured by impelling and supporting the torpid and feeble powers of the frame. But from the peculiar nature of the part or organ affected, the mode of treatment in the same degree and kind of inflammation will likewise be materially modified. Thus an asthenic affection of the liver requires different stimuli from an asthenic affection of the stomach.

Again, although in inflammation, as in fever, we generally recommend the cool treatment, and consequent free admission of air, it is to be recollected that this principle is objectionable in some kinds of inflammations, as of the lungs. For example, in small-pox and in measles, we shall have the same degree of pyrexia, or fever, present; and cold air would be equally indicated in either, were we to infer the proper method of treatment alone from the inflammatory excitement; but in measles the lungs are often the principal seat of the local affection, an oxygenous or pure atmosphere would prove too stimulating to these organs; and thus if we pursued general doctrines without particular exceptions, or overlooked "the peculiar nature of the part or organ injured," the object of our plans would be frustrated and defeated.

As it relates to this important principle in medicinal agency, the system of Dr. Brown is exceedingly deficient. The peculiar susceptibility of the separate organs our author overlooked in the rapid and general survey which he took of the animal economy.

Genus I. *Ophthalmia,* inflammation of the eye. See Surgery.

Genus II. *Phrenitis,* inflammation of the brain. This, as a sthenic affection, independantly of proper maniacal disorder, or febrile affection, is an extremely rare disease.

Symptoms. Redness of the face and eyes, impatience of light and sound, watchfulness, and furious delirium.

Methodus medendi. Copious evacuations. "Foment the head with cold water for hours together." Blisters. Blood to be drawn from the temporal artery.

N. B. The delirium of fever, which has been supposed to indicate an inflammation of the brain, is for the most part of an asthenic nature, and requires stimuli.

Genus III. *Cynanche,* quinsy.

Species 1st. Cynanche tonsillaris, common inflammatory sore throat.

M. M. Bleeding. Acid gargles. Saline purgatives. Blisters. Antimonial diaphoretics.

Species 2d. Cynanche maligna. An accidental, but very common, symptom of scarlet fever. See SCARLATINA.

Species 3d. Cynanche trechealis, croup. See INFANCY.

Species 4th. Cynanche pharyngæa, a mere extension into the pharynx of the cynanche tonsillaris.

Species 5th. Cynanche parotidæa. The mumps is an affection of the parotid and maxillary glands, which appears in the form of a swelling under the jaws: it is more common in some than in other counties of England. It sometimes appears as an epidemic. The mumps is in itself a slight disease; but after its declension, which is in general about the fourth day, the testes in men, and breasts in women, are very apt to be affected with swelling, in consequence of some peculiar sympathy of these parts with the throat.

M. M. If delirium supervene upon the retrocession of the swellings, blisters. "Foment the head with warm water." Darwin.

Genus IV. *Pneumonia,* inflammation of the lungs.

Genus V. *Carditis,* inflammation of the heart or pericardium.

Genus VI. *Peritonitis,* inflammation of the peritoneum.

The disorder which is usually termed inflammation of the lungs varies in some measure its seat. Thus the diseased action shall be directed towards that part of the pleura which is called the pericardium, and then it may be called carditis; or it may pass down the diaphragm, or the peritoneum, and form the peritonitis of Cullen, the diaphragmatis of Darwin.

The general symptoms, are, pyrexia, pain in the chest, difficulty of breathing, cough; and, if the disorder happen in the sthenic diathesis, the pulse is hard and frequent. Sometimes the expectoration is tinged with blood.

The particular symptoms are, in carditis, palpitation, with unequal intermitting pulse, pain in the region of the heart, vomiting, fainting: if the inflammation be particularly directed to the diaphragm, the pain is situated towards the lower ribs, the respiration in a recumbent posture is extremely difficult, and the corners of the mouth are sometimes so retracted as to form a disagreeable smile, called risus sardonicus.

M. M. It is of the utmost importance to attend to the prevailing diathesis. If the constitution is sthenic, and the disorder urgent, immediate and copious bleeding. Refrigerant and emollient cathartics. Cool and equal, not cold and irregular, atmosphere. Diluent drinks. Total abstinence from animal food, sometimes during the first five days. Antimonial preparations. After venesection a blister on the pained part. Digitalis. In Dr. Currie's Medical Reports we find the following observations: "I have employed the digitalis to a very considerable extent in inflammations of the brain, of the heart, and the lungs; and have succeeded with it in cases where I otherwise should have despaired." In Dr. Reid's Treatise on Consumption we meet with an acquiescence in this sentiment on the fox-glove. Our experience, however, has taught us to value this remedy principally in other pulmonary affections than the more violent kinds of inflammation, as is mentioned under the head of phthisis. After the excitement has been moderated, opium in small doses. "Do neutral salts increase the tendency to cough?" Pediluvium. Small doses of calomel, to prevent adhesions.

N. B. If pneumonia run on into suppuration pus will be discharged by cough, and thus a species of consumption be formed; or will be detained in the cavity of the chest, and constitute empyema. In either case, digitalis in large doses. Calomel. Opium. Peruvian bark.

Genus VII. *Gastritis,* inflammation of the stomach.

Symptoms. Violent pain in the region of the stomach, with pyrexia; small, frequent, and sometimes contracted, pulse; vomiting; hiccough.

Causes. It may be occasioned by any thing acrid taken into the stomach; by blows on the region of this organ; and a slight species of it is often consequent upon taking cold liquids after exercise.

M. M. In inflammation of the stomach and bowels we have, in some measure, an exception to the general rule of cure, according as the disease appears sthenic or asthenic. The pulse and vital powers are often suddenly reduced, and yet venesection is required. Warm bath. Fomentations. Anodyne and mucilaginous clysters. Blisters on the pained part.

Genus VIII. *Enteritis,* inflammation of the bowels; fixed and distressing pain in the bowels. Pyrexia; pulse always quick, sometimes hard.

Causes. The same as of gastitis. Likewise strangulated hernia, spasmodic colic, introsusception.

M. M. The same as in gastritis after the urgent symptoms have subsided. Small doses of calomel and opium.

Genus IX. *Hepatitis,* inflammation of the liver.

Symptoms. Pain in the region of the liver, extending to the clavicle and top of the right shoulder; difficulty of lying, on the left side especially. Pyrexia; high coloured urine; pulse frequent, strong, and often hard. Bilious evacuations, or jaundice. The tendency of the disease is to suppuration.

M. M. Copious and repeated bleedings before the suppurative process has commenced. Calomel, and cathartics of the refrigerant class. Digitalis in considerable doses. Blisters to the region of the liver.

If supparation takes place, the matter makes its way through the lungs, or the intestinal canal, into the cavity of the abdomen, or through the peritoneum to the surface. During this process opium and bark.

N. B. The disease above described is principally an affection of warm climates. A species of chronic hepatitis is more usual in Britain, and indeed is one of the most common maladies, especially among dram-drinkers.

Symptoms. Obtuse and weighty kind of sensation in the region of the liver; difficulty of lying on the left side;

pain in the right shoulder; the countenance slightly marked by hectic; dejection of spirits. Œdema of the ancles.

M. M. Small doses of calomel, with, or without, opium. Tonic bitters, such as quassia, or gentian. An abstinence from spirituous liquors.

Genus X. *Splenitis*, inflammation of the spleen.

Symptoms. Tension; tumor; heat of the left side; pyrexia; pain increased by pressure.

M. M. Venesection. Blisters, cathartics, calomel, and digitalis.

Genus XI. *Nephritis*, inflammation of the kidneys.

Symptoms. Pyrexia; pain in the lumbar regions; retraction of the testicle; numbness of the thigh; vomiting; costiveness.

Causes. Aternations of heat and cold; external violence, &c. as in other inflammations but chiefly calculi.

Distinctions. Nephritis is distinguished from lumbago by the more confined situation and pungent character of the pain; by the presence of pyrexia; and by there being in the latter no retraction of the testicle, or numbness of the thigh. It is distinguished from incipient psoas abscess, by the pain of this last being principally seated in the vertebral column; by such pain being increased on pressure of this part; and by its taking the course of the psoas muscle. See Surgery.

M. M. Venesection. Digitalis, and opium. Nitrous æther. Emollient clysters. Castor oil. Demulcents.

Genus XII. *Cystitis*. Inflammation of the bladder.

Pyrexia. Pain and tumor above the pubes; pain in discharging urine; tenesmus.

M. M. Venesection. Warm bath. Anodyne clysters. Diluents.

Genus XIII. *Hysteritis*. Inflammation of the womb.

Heat, pain, tension, and swelling in the lower belly; pyrexia; vomiting.

M. M. Venesection. Mucilaginous clysters, with opiates. Anodyne fomentations.

Genus XIV. *Rheumatismus*.

Pyrexia; pains in the joints, frequently extending along the muscles; heat and tumor on the part.

Peculiarities. Rheumatic inflammations never, like others, terminate in suppuration. Dr. Darwin attributes this circumstance to the secondary and associate nature of the disease; the original cause, like that of the gout, not being in the inflamed part; and therefore not continuing to act after the inflammation commences. Perhaps the peculiarity would be more properly referred to the nature of the parts that rheumatism attacks.

Division. Rheumatism is sthenic, or asthenic: the latter, or chronic rheumatism, often succeeds to the former; which the author just quoted refers to the deposition of mucus, or coagulable lymph, which the inflamed vessels had poured out in the first stages, remaining unabsorbed on the membranes of the joints. It would probably be more correctly attributed to the loss of energy in the parts affected: an opinion which appears to receive support from the circumstance of the asthenic form of the complaint sometimes coming on in a direct way, without the intervention of the acute species.

M. M. Bleeding would appear to be indicated in the sthenic kind of rheumatism: in this disorder, however, the physician is so often unexpectedly foiled by the rapid occurrence of indirect debility, that venesection is not often adviseable. In the acute rheumatism of the United States, blood letting is generally practised, and found absolutely necessary to give efficacy to the subsequent treatment in subduing the disease. Leeches to the inflamed joints. Volatile embrocations after the inflammation has in some measure subsided. Calomel, and opium. Sudorifics. Warm bath. "I have found digitalis an excellent remedy in inflammatory rheumatism, one of the most tedious and intractable of all diseases." Dr. Currie.

Peruvian bark in chronic rheumatism. Volatile tincture of gum guaiacum. Flesh-brush. Sea-bathing. Electricity. Bath waters.

Genus XV. *Odontalgia*, tooth-ache. See Surgery.

Genus XVI. *Podagra*, gout.

Symptoms. Pain in the joints, principally of the great toe, and especially of the hands and feet, returning at intervals. Previously to the accession of the inflammation the functions of the stomach are generally disturbed. The fits generally come on in the morning.

Causes and peculiarities. Gout is produced in a system predisposed to its influence by the indirectly debilitating powers; such as a too liberal indulgence in fermented and spirituous liquors, high-seasoned meats, &c. and likewise by the directly debilitating powers of vegetable and watery food, depressing passions, &c. The inflammation of this disease often alternates with, and appears in a manner vicarious of, torpor in other parts of the system; as of the brain producing apoplexy, the stomach constituting dyspepsy, and of the liver giving rise to jaundice: all which symptoms indeed may be considered as part of the disease. On this account gout has been divided into the atonic; that is, where a disposition to the inflammation of the foot is observable, but does not actually take place; the retrocedent, where, after the continuance for some time of such inflammation, it shall seem to be transferred to another part, and thus form a gouty inflammation of the stomach, or other organs; and, lastly, the misplaced, in which the gouty tendency, instead of displaying itself in its ordinary course, falls upon some other organs, as the lungs, the stomach, or the brain.

Dr. Darwin supposes "the original seat of the gout to be the liver, which is probably affected with torpor not only previous to the annual paroxysms, but to every change of its situation from one limb to another." For this principle of associate action there does not, however, appear sufficient support; and indeed the sympathy is displayed with more force and frequency between the inflamed foot and the organs we have above mentioned (the stomach, the lungs, and the brain), than the hepatic viscus. It is indeed the nervous system, and not the glandular, with which the paroxysm of the gout appears to have the most intimate connection; and it would have found a more appropriate place under the head of nervous diseases, than where it now stands in the Nosology. It is, however, very often combined with calculary disorders. The predisposition to gout is evidently hereditary; but the attacks of this malady may, in general, be warded off, even from the most susceptible habit, by a temperate mode of living. This principle is illustrated in an extraordinary manner by the history of Dr. Gregory, the present professor of the practice of medicine in Edinburgh. We have often heard him in his lectures produce his own

as an instructive case of the beneficial effects of an abstinence from fermented and spirituous liquors. Gout has been imagined, like fever, to be a sanative process of nature for the purpose of expelling something from the constitution. The doctrine, in either instance, is equally erroneous.

M. M. Dr. Beddoes, in his Hygeia, says, that one of the greatest martyrs to gout he ever met with informed him, " that his freest year was that of a warmly contested election, at which he was candidate for a county. He both drank and exerted himself at this time more than at any period of his life." The physician must be extremely careful in his application of the remedy introduced into practice, the application of cold water to the inflamed part. In some violent cases this may be proper; but it should never be extended beyond the limit of pleasurable sensation. To bleed is likewise hazardous in the extreme. Dr. Brown's mode of suspending the paroxysms has already been referred to; and every arthritic experiences temporary benefit from his dinner, his glass, and pleasurable company. It is by acting on the imagination that empirics suspend the threatened attacks of gout. In this, as in numberless other instances, faith in, constitutes the virtue of, remedies; both therefore in chronic rheumatism and gout, we might place among the curative agents metallic tractors, whether authorized by Perkins, or formed of old nails, as in the instructive experiments of Dr. Haygarth. Even a piece of sealing wax, or stick, when supposed by the patient to be the genuine tractors, operated in a most astonishing manner. (Haygarth on Perkins's Tractors.) The influence of the imagination over the body, whether in health or disease, has not been sufficiently acted upon in the professional practice of medicine. The irregular affections in gout must be combated by stimulants carefully adapted to the excitability; for the spasmodic affections of the stomach aromatics and bitters, as ginger and quassia. If the head is affected camphor, musk, ether, opium; these likewise are remedies for the gouty asthma. The Portland powder, which is a composition of bitters and aromatics, may prove for a time highly useful; but the protracted use of medicines of this class is objectionable, as eventually detrimental to the stomach and general fibre. Regular and steady, and not capricious and merely temporary, abstinence from wine, spirits, and spices. The body to be preserved gently open. Pure air, moderate exercise, encouragement of cheerful habits. Warm and cold sea-bathing. Bath waters. Very small doses of digitalis. Hop (humulus lupulus)?

Order III.—*Exanthemata*, Eruptions.

The exanthemata are more nearly allied to genuine fever than those disorders of which we have just been treating, as the local affections are consequences rather than causes of the general irritation. They have been called eruptive fevers. They are defined by Cullen contagious diseases, affecting a person only once during the whole of life, commencing with fever, and succeeded by eruption on the skin. The contagious matter upon which these depend may indeed operate upon certain parts more particularly, and thus the disease be entitled to rank among the sensative, irritative, or symptomatic fevers. This, however, is by no means certain: the primary action of contagion, whether of a specific or general nature, has hitherto escaped the penetration of the pathologist.

Genus I. *Erysipelas*, St. Anthony's fire.

Symptoms. This disease does not correspond with the whole of the above definition; it is not contagious; and it has frequently been found to recur. The face is the more ordinary seat of this affection. After febrile irritation has commenced, and continued for a short time, during which there is often an unusual drowsiness, and sometimes delirium, the face suddenly becomes bloated, the eye-lids swell, and the skin is red and blistered. If the disorder is violent, or ill-treated, the inflammation and redness extend down the neck, and spread sometimes on the shoulders; the tumid appearance of the countenance increases; delirium supervenes, and the patient has been known to die apoplectic. The erysipelas is an erythematic inflammation. Its seat is the rete mucosum. Its tendency is to gangrene rather than to suppuration. A fatal termination is said to be principally on the 7th, 9th, or 11th days.

M. M. In no other affection is it of more urgent moment to decide on the treatment by the nature of the prevailing diathesis. It has been observed, that in large and populous cities St. Anthony's fire almost always appears in the form of asthenia; and in this case requires wine, bark, opium: while in the hardy constitution of the rustic it assumes a sthenic character, and demands the vigorous employment of what has been called the antiphlogistic regimen. Venesection. Saline purgatives. Diluent drinks. Might not digitalis be employed with a prospect of singular advantage, as the disease has an evident affinity with certain species of dropsy? With respect to external application, it has been customary to use mealy substances, such as flour. Solutions of lead, zinc, or alum, are improper, " as they stimulate the secerning vessels into too great action." (Darwin.) Cold water. Blisters to the part have of late been found important remedies in this species of inflammation.

Genus II. *Pestis*, the plague, is an epidemic typhoid fever.

Genus III. *Variola*, small-pox.

Symptoms. After the pyrexial symptoms have continued for three days, eruptions appear on the skin, which on the eighth day contain pus, and at length fall off in crusts.

Species. The small-pox is divided into the distinct, and confluent: the first has more of the sthenic, the latter of the asthenic, character. In the former the eruptions are of a phlegmonic, in the latter of an erythematic or spreading, nature. The eruption of the distinct small-pox makes its appearance in circumscribed red spots on the face; in the course of two days the body and legs receive their portion. The fever now ceases, the face swells, the pustules enlarge, and on the eighth day are mature. The swelling of the face now goes off, and the hands and feet begin to swell, with a slight return of fever, which however soon declines.

In the confluent, or asthenic, species, the fits are not so regular; the eruptions are not circumscribed and prominent, but diffused, and scarcely appearing above the skin; a kind of erysipelas sometimes precedes them, and

every symptom denotes debility. The fatal termination is often on the 11th day.

Inoculation. The advantages of inoculation for the small-pox need not be insisted on. The circumstances, however, upon which depends the more favourable character of inoculated over natural small-pox, does not appear to have been satisfactorily accounted for. The only cautions requisite in preparing for inoculation, are to preserve the bowels free from sordes, and to choose a time for the insertion of the matter when teething, or other irritative processes, are not going on in the system. With respect to the time, it has been well said, that inoculation ought to be performed either before the second month, or after the second year.

M. M. Cold air. The bowels to be preserved open. Animal food to be denied. If the fever runs high, antimonials and nitre. In the confluent species, the alimentary and intestinal canal is with the utmost solicitude to be preserved free from congestions by purgatives, and the powers of the system supported by opium, bark, small doses of nitre, wine, pure air; vinegar aspersed about the bed, walls, and floor, of the apartment. Pediluvium.

N. B. For an account of the vaccine disease, or cow-pox, see the article VACCINATION.

Genus IV. *Varicella.* The chicken-pox is a very slight disease; the eruptions sometimes assume nearly the character of the distinct small-pox; but there is not much irritation of the system, and they generally disappear in the course of three or four days from their first breaking out.

Genus V. *Rubeola.* Measles.

Symptoms. Pyrexia, sneezing, inflamed eyes, dry cough, drowsiness; about the fourth day, or later, small red points appear on the skin, which in the course of about three days fall off in branny scales.

"As the contagious material of the small-pox may be supposed to be diffused in the air like a fine dry powder, and mixing with the saliva in the mouth to infect the tonsils in its passage to the stomach, so the contagious material of the measles may be supposed to be more completely dissolved in the air, and thus to impart its poison to the membrane of the nostrils which covers the sense of smell; whence a catarrh with sneezing ushers in the fever." Zoonomia.

M. M. Measles too often lay the foundation of pulmonary consumption, to prevent which the symptoms denoting inflammation of the lungs are to be with much solicitude obviated; and for this purpose venesection is often necessary. Small doses of tincture of digitalis are to be preferred to every other medicine. Steady and cool atmosphere, not cold air in currents. Refrigerant cathartics, with calomel. Animal food not to be given. Digitalis, with a very small quantity of opium, for the cough succeeding to measles.

Genus VI. *Miliaria*, miliary fever, is merely a symptomatic eruption of small red pimples about the neck and face, which in two days become white pustules, and desquamate. They have a peculiar smell. Much anxiety and difficulty of breathing precede the eruption. This disorder appears to be a consequence of an improper heating regimen in fever.

Genus VII. *Scarlatina*, scarlet fever.

Symptoms, &c. After pyrexia has lasted about four days a scarlet eruption appears on the skin, sometimes attended with inflamed tonsils and cervical glands: these last sometimes appear without cutaneous eruption, and the disease has been called cynanche maligna. This disorder is apt to be mistaken for measles; but in scarlet fever there are no catarrhal symptoms as in measles. This disorder is very irregular in its aspect; and often, without much care, fatal in its termination. Sometimes, without any alarming symptoms in the onset of the fever, a change takes place, and in the course of a few hours the patient falls into the arms of death. The unfavourable symptoms are the same as in other fevers. It is a disease principally of children. Whether it depend upon specific contagion, like measles and small pox, is not perhaps fully ascertained.

M. M. Cold affusion. Cold air. Antimonials, opium, bark, wine, saline purgatives or enemas, nitre, blisters. See the section on Fever in this article.

Genus VIII. *Urticaria*, nettle-rash. After pyrexia for a day, small red spots, like the stinging of nettles, appear on the skin, which almost vanish during the day, but return in the evening. It scarcely requires any medical treatment. The disease does not last more than two or three days.

Genus IX. *Aphtha*, thrush. Spots on the fauces and tongue, by which this disorder is constituted, are almost always symptomatic of other diseased states.

Genus X. *Pemphigus*, "a fever attended by successive eruptions of vesicles about the size of almonds, which are filled with a yellowish serum, and in three or four days subside." The treatment is to be regulated by the nature of the attendant fever.

ORDER IV.—*Hemorrhagiæ*, Discharges of blood.

The definition of this order is, pyrexia, with profusion of blood, without any external violence; blood when drawn from a vein showing the buffy coat. Discharges of blood, however, are often unattended with pyrexical irritation, and indeed for the most part are evidences, not merely of local, but also of general weakness. Augmented energy in the larger propelling vessels may indeed overcome the resisting power of the smaller branches, and produce what is called active hemorrhage; in this case we have only local debility to contend with in the cure. Dr. Darwin divides hemorrhage into the arterial and venous, the latter of which he attributes to defect of venous absorption; it does not appear, however, that the veins act in the manner of absorbents, according to the opinion of our author. Venous hemorrhage depends upon general weakness, accidentally directed to the vessels from which the blood is poured out by rupture of their coats. It is always a highly asthenic disease.

Rupture of blood-vessels, and consequent hemorrhage, has been ascribed to an immediate and primary change effected in the constituent particles of the vital fluid. This supposition, however, seems to be totally unfounded; even in the most active hemorrhage the blood does not undergo "orgasm, ebullition, turgescence, or expansion," according to the theory of Hoffmann.

Genus I. *Epistaxis*, bleeding from the nose.

Symptoms. Pain or fullness of the head, giddiness, dimness of vision, drowsiness, irritation of the nostrils. It is the disorder principally of young persons, who have a lax and weak fibre; in some few instances it occurs as vicarious of obstructed menses, and sometimes appears in men when the hemorrhoidal discharge has been suddenly arrested.

M. M. Cold applied to the neck and head. Mechanical pressure, or absorbing substances, to the nostrils. Acids and astringents internally. Avoiding irritation of the body or mind. The bowels to be kept gently open. Nourishing but not stimulating aliment. In the epistaxis of old people, and in cases of much weakness, bark, vitriolic acid, opium. If the disorder is violent, and have depended upon the suppression of some other discharge, such discharge to be restored.

Genus II. *Hemoptusis.* Spitting of blood. Symptoms. Redness of the cheeks, a sensation of weight in the breast, difficult respiration. Saltish taste in the mouth, irritation in the trachæa, coughing up of florid blood.

Hemoptysis more usually appears in individuals with a slender make and contracted chest, who are of an irritable habit, and who have been subjected in their earlier years to epistaxis. It generally comes on at the age of puberty.

Causes. Violent irritation of mind or body, sudden vicissitudes of heat and cold, too powerful exertion of the lungs, as in singing, coughing, playing upon wind instruments. Like epistaxis, and indeed more frequently, it immediately originates from obstructed menses. Sometimes it appears vicarious of a gouty paroxysm.

M. M. All irritation and irregularities to be carefully guarded against. Copious and repeated blood-letting often necessary. Bowels to be kept evacuated by mild purgatives. Manna. Tamarinds. Peruvian or oak-bark, combined with mineral acids, especially the sulphuric. Opium. Digitalis in large doses. so as to occasion nausea. "A table-spoonful of common salt." (Dr. Rush.) "One immersion in cold water, or a sudden sprinkling all over with cold water, would probably stop a pulmonary hæmorrhage." (Darwin.) Procure a return of the obstructed discharge.

Phthisis pulmonalis, consumption of the lungs.

Symptoms. Emaciation, weakness, cough, hectic fever, and for the most part an expectoration of pus.

Dr. Cullen has introduced pulmonary consumption into his nosology, as a sequel of hemoptysis. This common and fatal malady, however, often, and indeed for the most part, originates independantly of hemorrhage from the lungs. Its origin and progress are most usually exceedingly insidious. The persons chiefly obnoxious to phthisis, are those of a scrophulous habit, who have been disposed previously to suffer by lymphatic tumours, who are of a slender make, have long necks and narrow chests, who have been liable in their early years to bleeding at the nose, who have had frequent catarrhal affections while children, and in whom cough has remained or been ill-treated after the eruptive diseases of infancy, more especially the measles. These predispositions ordinarily break out into actual disease, at or shortly after the period of puberty. It is at this time that the pulmonary circulation becomes altered; and the seeds of the disease, hitherto latent, are expanded and developed.

In any constitution then at this period, and more especially in those that are characterised by a scrophulous tendency, a short and generally dry cough, succeeding perhaps to a trivial cold, attended with emaciation in the smallest degree, and more especially if the pulse be rapid, and the cheek be marked by hectic redness, alternating with more than usual paleness of countenance, the patient is to be assiduously watched, and the disorder earnestly combated.

Causes. Phthisical ulceration of the lungs, or confirmed consumption, is ordinarily produced through the medium of tubercles, or small bodies, in the cellular texture of these organs, which by repeated and gradual irritation, at length come to ulcerate and destroy the fabric of the lungs, and produce the symptoms of fully formed phthisis. The origin and actual nature of these bodies are not perhaps very evident; they were formerly erroneously imagined to be indurated lymphatic glands.

The more immediately exciting cause of pulmonary consumption is generally an exposure to cold, which operates in the manner described under the section Catarrh. Consumption, however, may be brought on by amenorrhœa, lues venerea, unseasonably repelled eruptive action on the surface, mental affections, &c.

M. M. "The facility," says a modern author, "of repressing the primary symptoms of phthisis pulmonalis, is proportioned to its difficulty of cure when the characters of the disorder are fully confirmed, and the texture of the lungs almost wholly destroyed." (Reid on Consumption.) In no case, perhaps, is neglect or early mismanagement of disease more pregnant with irremediable evils, than in the instance of consumptive affections. Venesection in the inflammatory stage, and low diet. Blisters to the chest. Digitalis properly and timely had recourse to is "the anchor of hope." "In families where this fatal disease (phthisis) is hereditary, the use of this remedy as a prophylactic, will, I have no doubt, save many lives that would otherwise have been cut short." (Dr. Currie.) "Digitalis is a remedy in pulmonary consumption in its earlier periods, which under due regulations, and with sufficient attention to other circumstances of regimen and diet, may be employed with a prospect of almost invariable relief." (Dr. Reid.) Other testimonies, equally decided, might be adduced in favour of this valuable remedy. Warm bathing. A regular temperature in the air that the person breathes. Warm clothing. Avoiding currents of air. Assiduously guarding against damp, and especially cold application to the feet, as by sitting with the feet on a stone floor, or an oil-cloth. Milk diet, of which Hoffman elegantly says, "Qua perplures phthisicos, in cymba Charontis quasi hærentes, sanatos, pristinæque redditos valetudini, novi." Avoiding all spirituous liquors, and spiced or high-seasoned meats. Keeping the bowels gently open by manna, castor-oil, senna, &c. Uva ursi has recently been recommended by Dr. Bourne.

These are the remedies of the first stage, or, more properly speaking, the menacing symptoms of consumption. When the lungs have actually become ulcerated after gradual and protracted irritation, very little expectation of recovery can remain. Griffith's mixture, composed of

steel, myrrh, and alkali. Digitalis in larger doses, and combined with the above tonic. Uva ursi? opium and vitriolic acid. Digitalis combined with calomel. Change of climate. If a tendency to absorption from the surface of pulmonary ulcer could be induced greater than the deposition of it, we might have some prospect of curing the disease in its advanced stages. In order to produce this absorption, sailing so as to occasion sea-sickness has been had recourse to. Swinging, riding in a carriage, and other modes of occasioning a degree of vertiginous affection, and consequent nausea, have likewise been recommended and practised. Inhalation of a lowered atmosphere, of other modified gases, and even volatile astringent substances, have been also proposed and tried, but not with decided benefit. Bath waters and cold sea-bathing are improper in every stage of the complaint.

N. B. If consumption be symptomatic of other diseases, while the symptoms are subdued by the above remedies, the attention must necessarily be turned principally towards the original affection.

Caution. All the signs of consumption may be present without the presence of the disease. Debility, emaciation, and cough, may be brought on by nervous, independant of organic disease, as well as by worms and intestinal viscidities. Hectic fever may be occasioned in certain constitutions by mental affections alone; this likewise is sometimes induced by worms. Purulent expectoration, indeed, is decisive; but the nature of the sputa is not with facility, in every case, to be decided upon.

Genus III. *Hæmorrhois,* the piles.

Weight and pain of the head, vertigo, pain in the anus and loins, swellings and flux of blood from the anus.

M. M. If symptoms of arterial activity accompany the hæmorrhoids, bleeding and laxatives first followed by vitriolic acid, with moderate astringents, such as infusion of roses. Temperance, exercise, abstinence from spirituous liquors and spices. Tamarinds. Lenitive electuary. Sulphur. Chrystals of tartar. Castor oil. Leeches. These two last remedies, are especially serviceable in what are called the blind hæmorrhoids, where there is swelling with pain from congestion in the hæmorrhoidal veins, without any discharge of blood from the anus.

When the hæmorrhoidal flux is attended with much debility, while the bowels are kept open by castor-oil and other similar purgatives, the more powerful astringents are to be employed. Steel. Exercise. Generous diet. Cheerful train of thinking. See SURGERY.

Genus IV. *Menorrhagia,* immoderate menstrual flux.

Symptoms. Pain in the back and loins, vertigo, difficulty of breathing, flushes of heat and cold, frequent pulse; in cases where the disease is more directly from debility, loss of appetite, paleness of countenance, coldness of the limbs, œdematous swellings about the ancles.

M. M. In the first species, the menstrual irregularity generally arises from hysteric or nervous affections, libidinous desires, and other violent passions; in this case attention must be paid to counteract the cause. Avoid stimuli of all kinds, mental or physical. Venesection if the pulse calls for it. Refrigerant cathartics, if costiveness be present. Moderate astringents, such as infusion of roses, and the sulphuric acid. In the menorrhagia of direct debility, astringents, cordials, and stimulants. Peruvian bark and sulphuric acid, opium, alum, port wine. External application of cold water, or vinegar. Steel. See MIDWIFERY.

ORDER V. *Profluvia.*

The profluviæ are distinguished by Dr. Cullen from hemorrhages, by the discharges not being naturally sanguinary. This order contains two genera, catarrhus and dysenteria, both of which might have found more appropriate situations even in Dr. Cullen's own nosology.

Genus I. *Catarrhus,* a cold.

Symptoms. Pyrexia, with increased discharge from the mucous membrane of the nostrils, and in violent cases of the fauces and bronchiæ, with cough.

The term cold, which is made use of, in common language, principally to denote an inflammatory condition of the mucous membrane of the nose, is exceedingly incorrect; it not only confounds the effect with the cause of the disorder, but conveys an erroneous idea of the mode in which such disorder is created.

The operation of cold, unless through the medium of the sensations, is invariably negative; it is merely an abstraction of the stimulant power of heat, and by its application to the living body (from an invariable law of organic existence) renders the frame in a more than ordinary measure susceptible of such, and other stimulant powers. For example: Suppose an animal to exist in a medium temperature of 60°, let 10° be subtracted for a short period, and afterwards precipitately added, the 60° will now act as with a power, perhaps, of 65, on account of the previous abstraction of stimuli producing, as it has been very properly expressed, "an accumulation of excitability." In this manner then is explained the agency of cold, in engendering inflammatory disorders, among which that we are now considering is one of the most frequent; an explanation founded upon a principle for the developement of which we are unquestionably indebted to the genius of Dr. Brown. This author, however, made an improper use of his own discovery; he did not sufficiently take into account the complicated and combined functions of the animal economy; and the very first position which he deduced from the detection of this important, and indeed characteristic, quality of living existence, is practically incorrect. "Cold applied to the animal system never proves injurious unless succeeded by heat:" frigus nunquam nocet, nisi ubi ejus actionem calor excipit. In endeavouring to support this assumption, Dr. Brown and his disciples have aimed to prove that those symptoms which are usually characterised by the appellation of a cold, as well as rheumatism, and all other diseases arising from exposure to cold, are not occasioned until the same or a superior degree of external heat be restored; forgetting that the "accumulation of excitability" immediately resulting from diminished temperature is acted upon, and thus inflammatory irritation engendered, by the remaining stimuli of the frame, external and internal. Thus an individual, while still exposed to the catarrh-producing temperature, while, for example, his feet remain wet and cold, shall have inflammation in the mucous membrane of the nose and fauces, febrile irritation, and all the usual phenomena of catarrh; the balance of excitement being overturned, and turbulent irritant action being established in its stead.

Further, the existence of a cold does not suppose the presence of a sthenic disease: indeed the exact contrary is the fact, for the malady will be occasioned with most facility when the frame is weak and irritable.

Why the membrane of the nostrils, &c. should be the readiest to suffer more particularly, does not seem to admit of an easy explanation; it is important, however, to recollect what has been pointed out in an explicit manner by Dr. Beddoes, and since by Dr. Reid, that this membrane is a part of the same expansion with that which lines the windpipe and enters the lungs; so that in fact common inflammatory cold is a degree of the same disease with an inflammation of the lungs.

M. M. Moderate and equal temperature. The bowels to be kept gently open. If the febrile irritation is considerable, blood letting, sudorifics. Antimonial, nitre. Oleaginous substances may be used to allay the cough; but irritating balsams, such as cough medicines are generally composed of, are in the highest degree detrimental; they too often increase the disposition to, and sometimes actually produce, confirmed consumption. Liquorice, honey, boiled fig, almond emulsion.

If the phthisical tendency is conspicuous, digitalis (see the section on Phthisis pulmonalis).

Genus II. *Dysenteria*, dysentery.

Symptoms. Frequent but small stools, mixed with mucus, and sometimes with blood, attended with griping and tenesmus, the proper alvine excretions being retained; pyrexia, pulse quick and feeble. The disease is sometimes contagious and epidemic.

Causes. Its predisposing and exciting causes are alternations of heat and cold, more especially when accompanied by damp, as when an army is encamped on marshy ground; the putrid miasma arising from the marshes; the contagious effluvia proceeding from the discharge in the disease; and, according to sir John Pringle, from dead bodies left unburied in the field of battle. It is likewise occasioned by unwholesome and putrid food.

The immediate cause of the symptoms seems to be, a spasmodic constriction of the larger intestines, retaining the fæces.

M. M. Castor-oil, calomel, opium, and rhubarb, to relieve the spasm, and discharge the contents of the bowels. Mucilaginous clysters, as of starch with tincture of opium. Emetics. Small doses frequently repeated of ipecacuan. Colombo. Peruvian bark. Warm bathing.

Class II. *Neuroses*, Nervous diseases.

Man is indebted for all his acquisitions to casual observation, leading to experiment. That the faculty we call the sentient resided in, or was developed through, the instrumentality of a peculiar and distinct organization, we should not, a priori, have conceived; there is nothing in the composition either of brain or nerve to lead to this conjecture. If, however, a portion of the bony defence of the encephalon be accidentally pressed in upon its substance, and an interruption in the faculties of sensation and voluntary motion be the consequence; if such accident be repeated with the same result; finally, if it be found, as it has been, that by voluntarily producing pressure on this organ, similar effects may be occasioned in proportion to the degree and extent of the force employed; the inference will come at length to be indisputable, that the brain is the organ or reservoir of sensation, and the medium through which loco-motion is effected.

Again, if it be found that at pleasure we can deprive any portion of the body both of sense and motion, by dividing the nerve supplying such part, or cutting off its communication with the brain, we are likewise fully justified in inferring, that the chord we have severed was the instrument by which the empire of the will had been exercised over the now inert and useless member.

It is by the aggregation of such observances that we arrive at the pathology of nervous, as a distinct class of morbid affections. When, for example, any particular member of the body suddenly refuses to obey the command of the will, or, in common language, becomes paralytic, although we may not be able to trace the remote cause from which this has originated, we know that it must have immediately depended upon some morbid change, either in the brain itself, or at least in the nerve supplying the organ indisposed.

This mode of inferring the nature of what is not an object of our senses, by comparing it with what we actually observe, will be found equally satisfactory, in relation to partial as total interruption of sense and motion; thus, by a less degree of injury done to a nerve, as by lacerating or puncturing, instead of dividing it, we shall perceive not an entire deprivation of, but merely an impediment to, the loco-motive faculty; the actions of the member will be in a manner refractory; and convulsive or irregular, instead of orderly and steady, motion, will follow the mandates of the will.

If then, without the interference of an experimenter, and without visible injury to the animal structure, the movements of an organ become improperly accelerated, or cease to be exercised in their usual mode; if, to instance by example, the heart perform two feeble, in place of one full and vigorous contraction; we are authorized to state, that the disorder thus constituted is strictly and properly a nervous affection; and our conclusion, as to the fact, will be precisely the same, whatever theory we incline to, respecting the quo modo in which nervous power is displayed; whether with Hartley we conceive it to depend upon vibrations and vibratiuncles, whether we embrace the doctrine of universally pervading æther, or subscribe to the untenable positions of the author of Zoonomia.

Depraved perception and interrupted motion, are therefore the essences of nervous disease: the percipient, however, is to be distinguished from the motive faculty; for we have a class of living actions, which, although equally under the influence of nervous power with those over which the will presides, are nevertheless, in a state of health, incessantly carried on without perception or consciousness; thus, by impeding the functions of the nerves of the stomach, we may interrupt the function of digestion. Digestion, however, is a process performed without design, and independantly of volition; on the other hand, the intellect may be impaired by a derangement in the nervous system, while the digestive power shall proceed without the smallest hindrance.

Dr. Cullen's definition of a nervous disease, would therefore have been more accurate, had he stated it to be an affection of either sense or motion, without idiopathic

pyrexia, or visible disease of parts. The orders of this class (neuroses) are four:

1. Comata. A diminution of voluntary motion, with sleep or impaired senses.

2. Adynamiæ, a diminution of the involuntary motions of either natural or vital functions.

3. Spasmi, morbid motions of muscular fibre.

4. Vesaniæ, disorders of the judgment or intellect without primary pyrexia, or observable affection of any particular part of the body.

ORDER I. *Comata.*

Genus I. *Apoplexia*, apoplexy.

Symptoms. Abolition of the sentient and loco-motive faculties, the sleep in general attended with snoring. The respiration, motion of the heart, and other involuntary actions, remaining.

Causes. We conclude from the analogy above-stated, that there is some degree of pressure on the brain in almost all cases of apoplectic stupor; but that effusion of blood takes place in the manner described by the generality of authors, is exceedingly problematical; if the appearances on dissection are appealed to in behalf of this theory, it is answered, that such appearances can alone apply to fatal cases of the disease; and in such, an actual rupture of vessels and effusion of blood will readily be admitted.

Epilepsy, palsy, and apoplexy, were contended by Brown to originate from the mere irregularity of nervous power consequent upon debility or deficient excitement; and to be occasioned without either an unusual impetus of circulation to the vessels of the brain, or impeded return of blood from this organ. We believe, however, that although the cause of apoplexy often is in one sense mere deficiency of excitement directed to the sentient organization, the immediate occasion of the apoplectic symptoms is for the most part the state of the vessels of the brain.

Apoplexy, for the sake of illustration, may be divided into sthenic and asthenic. If a vigorous and plethoric man, sitting down to his dinner and his glass, suddenly, during the excitement of conviviality, of mirth, and of alcohol, fall on the floor with deprivation of sense and apoplectic stertor, it must be evident that the fit has been induced by a greater flow of arterial blood into the vessels of the brain, than the veins of this organ could, in due time, convey away. The apoplexy has been induced in the manner of a sthenic disease.

If, on the other hand, a debauched and debilitated individual be the subject of an apoplectic attack, at the time when the excitement of intoxication shall have been succeeded by the condition of indirect debility, the disease will here have been brought about in a different manner; the impetus in the vessels of the brain shall have partaken of the general diminution of power throughout the whole system; sluggish vascular action shall have caused congestion; which congestion, in union with the deficient excitement on which it had depended, shall have induced that sudden suspension of the sentient faculty which constitutes the apoplectic paroxysm.

Apoplexy often immediately succeeds to a full meal: what more natural than, under such circumstances, to attribute the fit to a distended stomach pressing upon the aorta or large descending blood-vessels, and consequent determination of the vital fluid in an inordinate measure to the head? Such conclusion, however, will not bear the scrutiny of strict inquiry. Upon this principle, the apoplectic stertor and insensibility ought to be induced with most readiness, as in oneordynia or night-mare, while the body is in a recumbent posture, and the stomach is most distended from the extrication of gas which takes place in consequence of the weakened digestive power; in place of this, however, the fall is immediate; the attack is made while the body is in an erect position, and often before the stomach has become in a very great degree distended; the fit then arises, in this last case, from that degree of excitement which the digestive powers have called off to their aid, leaving the brain in a condition of insufficient energy, properly to propel the vital fluid through its own vessels; congestion of blood is the consequence, and this last the proximate or immediate cause of the fit.

M. M. The strictest attention to the manner in which the disorder has been brought on. If the disease is sthenic, and the physicians are called in while the paroxysm still continues, immediate and copious bleeding from the arm, the jugular veins, or the temporal artery. Every ligature about the patient's body, especially about the neck, to be loosened immediately. Press hard with the thumb and fore-finger upon the carotid arteries, taking care to avoid the jugular veins. Place the head of the patient high on his pillow, or seat him erect in a chair. Preserve the apartment cool. Cold water may in some cases be applied vigorously to the forehead and temples. Afterwards saline purges, and subacid drinks. Enemas. Careful preservation from irregular and violent excitations, either of body or mind. In the asthenic, and by far the most usual form, of the complaint, bleeding with much less freedom and only during the paroxysm; in general, it is not at all proper. It is better to open the temporal artery, if convenient, than to bleed from the arm or jugulars. The application of cupping-glasses still preferable; apply blisters to the neck. When the power of deglutition has returned, cordials and stimulants. Opium and wine in very small doses. Volatile alkali. Sprinkle vinegar about the room. To prevent the returns of the fits; tonics, particularly bitters, as colombo, gentian, quassia; exercise and mental amusement, without violent excitation. Journeys to Bath or elsewhere. Preserve the body regularly open, without violent purgations. Avoid sudden exposure to cold, especially cold and wet feet. If the fit has followed the suppression of any accustomed discharge, or cutaneous eruption, let them, if possible, be restored.

Genus II. *Paralysis*, palsy.

Partial interruption of the loco-motive faculty, sometimes with a degree of apoplectic stertor.

This is partial apoplexy, arising from similar causes operating in a less degree. It sometimes succeeds to a full fit of apoplexy, and continues for months, or during life. The palsy often affects the whole of one side, and is confined to that side; hence it has been supposed, that the injury of the brain is likewise partial; and from the decussation that has been imagined traceable of the nerves from the encephalon, Dr. Darwin and others have concluded, that the origin of the disease is on that side of the brain opposite to the affected side.

Palsy, however, certainly originates at times (even if genuine apoplexy does not) from interrupted excitement, without any congestion in the brain, as its more immediate source, as when it results from the poison of lead and other causes.

M. M. Ascertain the exciting cause, and if possible, counteract it. Emetics; purgatives, preceding stimulants and tonics. Tonics and stimulants the same as in asthenic apoplexy. Volatile embrocations to the paralyzed side or limb. Warm bath. Bath waters. Electricity. Galvanism.

N. B. Fatuity, or second childhood, very often takes place through the medium of paralytic affections; the faculty of memory appears to be overthrown by the associate sentient actions, which constitute this faculty, being dissevered beyond the power of reunion; and existence is reduced, in consequence, to a state of mere vitality from immediate impression. This is not seldom the case when the loco-motive power, and the energy of the muscular fibre, shall have been restored to their former state. In this case the recollection of the past, and anticipation of the future, have both probably been irrecoverably lost.

The mere possibility of his being reduced to this condition of humiliating existence, one would think a motive sufficiently powerful to check the intemperate in his course.

Order II. *Adynamiæ.*

Genus I. *Syncope*, fainting.

Symptoms. A diminution, or even, for a time, a total cessation, in the action of the heart.

Fainting may arise from passions of the mind; from sudden reduction of stimulus, as from bleeding, or drawing off the waters in dropsy; violent pain; the irritation of worms, or other crudities, in the stomach and bowels; much heat, offensive effluvia, &c.: in these cases the disorder has been called syncope cerebralis. When fainting arises from deficiency of oxygen in the circumambient air, as in a crowded assembly, the cessation of the heart is produced nearly upon the same principles as in actual suffocation, drowning, or strangling. It is then termed syncope pulmonea.

M. M. Immediately obviate, if possible, the exciting cause. Endeavour to restore sensation by aspersing cold water on the face and neck; attempt to force down a small quantity of brandy; and in all cases, but more especially when the affection arises from impure air, throw open the windows, and prevent compassionate spectators from crowding round the insensible patient.

N. B. If fainting, or palpitation, recur frequently, and without any manifest cause, either predisposing or exciting, there will be reason to suspect that the disorder is not nervous, but depends upon some malconformation in the heart, or neighbouring blood-vessels. In this last case it is irremediable.

Genus II. *Dyspepsia*, indigestion.

Symptoms. Deficient, or depraved, appetite; nausea; vomiting; inflation from flatulence; heartburn; pain in the stomach, especially when the body is in a bent position; oppressed breathing; costiveness.

This disease evidently arises from deficient action in the muscular fibres of the stomach, which in violent cases amounts to inverted motion and vomiting. It acknowledges the same sources as other affections of weakness: these are, intemperate use of spirituous liquors, and of tea; exposure to damp and cold; irregular hours of repose; intense study; mental depression and anxiety; when originating from this last source the disorder has an equal claim to the appellation of hypochondriasis, or low spirits, with that of dyspepsia.

M. M. Purgatives, with calomel, previously to giving tonics. An emetic. Colombo, gentian, quassia. Magnesia, in order to neutralize the acidity, and ease the consequent pain of heartburn if present.

Chalk, which is used with the same intention, is improper, on account of that neutral compound which it forms with the acid of the stomach being insoluble, and tending to increase the costive state. "The dyspeptic must be persuaded that a horse is the best physician; and that temperance of every kind, with reasonable disposition and exercise in a dry healthy air, will do more for him than all the medicines in the world." (Townsend.) Cold, or shower, bath, in very warm, and warm bathing in cold weather. A glass of warm water after dinner and supper.

Genus III. *Hypochondriasis*, low spirits.

Indigestion, with languor, and causeless apprehension of evil, more especially as it relates to the patient's state of health.

This disease and dyspepsia only deserve to be distinguished by separate names, inasmuch as the mental depression in hypochondriasis appears especially to increase the disease by which it is, in part, constituted; and such disease is again magnified beyond measure by the morbid imagination of the invalid. Thus, in some cases of confirmed hypochondriasis, the dyspeptic sensations shall be attributed by the sufferer to the immediate agency of a malevolent power.

M. M. Aim at converting solicitude and apprehension into confidence and hope; not by deriding the feelings of the hypochondriac, and treating them as fanciful; but by breaking the chain of diseased associations. Procure a gradual change of scene and of habits. Journeys to Bath, or elsewhere, according to the previous disposition of the patient. Bath waters. Warm bathing. Preserve carefully the alimentary canal free from colluvies and viscidities. Maintain a regular moisture of the skin, without copious perspiration. Tonics with aromatics. Dr. Darwin particularly insists, and with justice, on the advantage of uniformity in the hours of meals: this uniformity should even extend to medicinals, the same hour of repetition being invariably observed. "Siesta, or sleep after dinner."

Genus IV. *Chlorosis*, green-sickness.

Dyspepsia; paleness of the skin and of the lips; lassitude; difficult breathing, and palpitation of the heart, after using more exercise than usual, especially in going rapidly up stairs; pulse small, feeble, and sometimes very quick: coldness of the extremities; appetite deficient, and oftentimes depraved; pain in the back and loins; costiveness; œdematous ancles, especially towards evening; and obstructed menstruation. "Chlorosi laborat debilis puella totum corpus, laxo œdemate tumet; pallent et frigent omnia." (Van Swieten.)

Dr. Cullen has, with much impropriety, classed this

among the nervous diseases; it ought to have been transferred to the next leading division of disease, or rather regarded as an affection of the lymphatic and absorbent system. In cases of much debility, especially of disposition to torpor, in the absorbent and secerning vessels; if, at the time when nature demands a new secretion and discharge from the system, in place of generous living, due exercise, moderate and pleasurable excitation of the mind, "the ever-springing hope" of youth, &c. be substituted to poverty and unwholesomeness of diet, watery and vegetable food, inactivity; concealed, oppressing, ungratified, and hopeless desires; the effect is the disease now under notice: which, however, from much natural debility, independantly either of mental depression, unwholesome diet, or any other cause, may be, and very often is, occasioned. Chlorosis, indeed, is of exceedingly frequent occurrence.

The immediate cause is evidently an inactive state of the absorbent vessels, more especially of those which supply the chyle: hence deficiency of red blood in the vessels, want of propelling power in the heart and arteries: hence want of menstruation, œdematous swellings of the feet, "pallent et frigent omnia."

M. M. Almost as certainly as some kinds of pain yield to opium, does even obstinate chlorosis fall before the power of steel. "Dum hoc utitur, incipit oriri major calor." To steel, then, must the physician principally trust in every case of genuine green-sickness. It is necessary, however, frequently to commence with an emetic; and in almost all cases it is proper to give a purgative, joined with calomel, before the administration of steel. Tonic bitters. Aromatics. Moderate exercise in a pure atmosphere. Flesh diet. "A bath of about eighty degrees, as Buxton;" not by any means colder. Marriage.

Order III. *Spasmi*, Spasms.

In the introduction to the class Neuroses, we endeavoured to describe briefly the manner in which a knowledge was acquired of the separate functions and distinct diseases of the nervous system. In the case of spasmodic affections this is especially illustrated. If in any animal the nerve supplying a limb be denuded, and a violent stimulus be applied to its surface, the whole member shall be immediately thrown into convulsive agitations: a fact which is perhaps too often demonstrated in galvanic and other experiments. When then such convulsive movements appear, without experiments, and sometimes without apparent cause, a similar change is justly inferred to take place in the nerve or nerves passing to the organ which may be the subject of the disease.

Sect. I. *Spasmodic affections in the animal functions.*

Genus I. *Tetanus.* A spasmodic regidity of a great part of the body: in some instances it is drawn violently backward, at others forwards, and in both cases the disease is generally followed or attended by trismus or lock-jaw; these symptoms may last with greater or inferior violence from twenty-four hours to a month or more.

The immediate exciting causes of tetanus are, wounds or pricks of tendons; the sudden application of cold after extreme heat; great intemperance, or other vices: the disease may likewise be consequent upon viscid mucus, worms, and other irritating substances, in the alimentary passages.

M. M. As in fevers, it is highly necessary to preserve the alimentary canal free from colluvies, in order that the return of due and orderly excitement may not be prevented by this cause; so it is especially necessary in nervous and spasmodic affections carefully to keep in mind the incalculable importance of this principle. Indeed, among the actually exciting causes of the malady now under notice, these intestinal crudities are perhaps the most frequent. Let the practitioner then, in every spasmodic disorder, pay solicitous attention to the condition of the stomach and bowels: it is in these organs "that the archer may be seated," in whatever directions he may send out his arrows. It is not, let it be as carefully remembered, by the act of evacuation in reducing the system, that either emetics or purgatives operate thus beneficially; but by the disposition that a freedom in the first passages favours to the due succeptibility of the exciting powers, on the agency of which the return of health depends. Indeed, as far as either purging or vomiting are in themselves immediately instrumental in dissolving spasm, as it has been expressed, independantly of the source just referred to, it is by virtue of the agitation and stimulus, not by the discharge of which they are productive. (See Infancy.) Emetics, cathartics with calomel. Pouring large quantities of cold water over the body during the spasm, in order forcibly to sever the catenated motions by which it is constituted. Warm bathing. Very large quantities of opium. More than four hundred drops of the tincture have been given in some violent tetanic affections in the course of twenty-four hours, and without producing any intoxicating effect. Other antispasmodic medicines. Mercury. If the spasm has originated from a lacerated or punctured tendon, divide it freely, and produce pain and inflammation.

Genus II. *Convulsio*, convulsions. On the cause and treatment of these, we need not enlarge, after the remarks we have introduced on the nature, predisposing and exciting causes, of convulsive and spasmodic disorders in general.

Genus III. *Chorea*, St. Vitus's dance.

Symptoms. Convulsive agitations of the limbs, in general almost confined to one side of the body. When the patient attempts to walk, he produces involuntary gesticulations.

M. M. Emetics, cathartics with calomel; anthelmintics; bark, steel, and other tonics; electricity, galvanism, tepid bathing, sea-bathing.

Genus IV. *Raphania*, contractions in the joints.

Symptoms. Spastic contractions of the joints, with excruciating pain, and convulsive motions, returning periodically, and continuing for many days. It appears to be a species of rheumatism.

M. M. Purges, followed by tonics; mercury combined with opium.

Genus V. *Epilepsia*, epilepsy. Violent convulsions of the muscles, attended with sleep.

Epilepsy in its nature and causes appears to hold a kind of intermediate situation between apoplexy and convulsion; it has the sudden fall and the sopor of the one, with the irregular muscular action of the other. Epilep-

sy, in a great or less degree, is a disease of extreme frequency: indeed, all the convulsions of children may be called epileptic. In its full and formidable shape, it is not so frequently met with as several other diseases. A physician, however, may denominate, with propriety, all fits epileptic, of which alternate or combined convulsions and sleep constitute the characters, especially if these are connected in any degree with an increased action of the salivary glands.

M. M. Epileptic fits are sometimes congenital, hereditary, and depend upon some occult state of the nervous system. In these cases the disorder is generally irremediable. All that can be done by art is merely to ascertain, and endeavour, if possible, to obviate, the exciting causes of the disease; and during the paroxysm to loosen every bandage about the neck and head, preserve the apartment in which the fall is made as airy as possible, and be careful that the patient do not inflict injury upon himself by the violence of his agitation. In some cases, indeed, the individual can obviate the full formation of the paroxysm by tying a ligature round the limb in which the sensation threatning the attack is perceived, between the point at which such sensation commences and the brain. This sensation constitutes what is called the epileptic aura: its abstract cause is obscure; but no less so than the phenomena of spasm in general.

In treating the complaint, particular attention is to be given to the predisposing and exciting cause or causes, which are extremely numerous; such as youthful intemperance, indulgence in secret vices, mental passions and affections, imitation of other epileptics, lively recollections of previous impressions, repelled eruptions or discharges, sudden alternations of the extremes of temperature, unpleasant odours, and, as by far the most common source of those epileptic fits which scarcely amount to absolute epilepsy, worms. These causes must all necessarily be removed before the physician can have the least prospect of overcoming the disease. If plethora of the system be present, venesection. Emetics, cathartics, with calomel; anthelmintics: suddenly dissever the chain of associations, by plunging the patient in the cold bath, or dashing with violence cold water over his naked body. Induce a new disease, as the itch: a plan which Dr. Darwin adopted with success in the treatment of St. Vitus's dance, with which the present has a great affinity. Patients have likewise been cured of epilepsy, by the accidental occurrence of a quartan ague. These are instructive cases to the reflecting and speculative. Tonics. Galvanism. By this newly discovered source of nervous excitation, the writer of this article recollects to have witnessed a supposed cure of a very obstinate case of epilepsy. It is not, however, easy to ascertain how far remedies operate in overcoming gradually, chronic affections.

Of Worms, and Anthelmintics. Worms we have just stated to be among the most frequent of the exciting causes of epileptic fits. As the order of our nosology no where leads us to notice them in an especial manner, it may not be improper in this place to introduce one or two remarks respecting their nature and treatment.

Intestinal worms are of three kinds: the ascaridis, or small thread-like worm; the lumbricus teres, or round worm; and the tænia, or tape worm. The first of these are principally confined to the rectum: they are divided by Dr. Darwin into two species, viz. "the common small one, like a thread, which has a very sharp head, as appears in the microscope, and which is so tender that the cold air soon renders it motionless; and a larger kind, above an inch long, and nearly as thick as a very small crow-quill, and which is very hard in respect to its texture, and very tenacious of life." The symptoms by which the presence of these may be suspected, are an uneasiness and itching in the rectum, especially urgent towards the evening: this, if violent, disturbs sleep, and occasions febrile irritation, and sometimes tenesmus, with mucous discharge from the anus, indigestion, and itching of the nostrils.

M. M. Clysters of lime-water, injection of tobacco-smoke. Mercurial ointment introduced into the anus. Aloes and steel, both by the mouth and in the form of enema. Saline purgatives. Harrowgate water, so as to induce six or seven stools every morning.

The lumbricus is the most common. Its symptoms are enumerated in the article INFANCY. Lumbrici are of very different lengths and magnitude; they are principally found in the smaller intestines, but are situated occasionally both in the stomach and larger intestines. These worms have been known to pierce through the coats of the alimentary canal, and have thus occasioned most excruciating pains and death.

The tape worms are sometimes voided of an enormous length: they have been stated to be from two to forty feet long. They properly consist of an united chain of separate animals; as, when broken, each portion has the power of reproduction. "The worms of this genus possess a wonderful power of retaining life. Two of them, which were voided by a pointer dog in consequence of violent purgatives, each of which was several feet in length, had boiling water poured on them in a bason, which seemed not much to inconvenience them. When the water was cool, they were taken out, and put into gin or whisky of the strongest kind, in which their life and activity continued unimpaired, and they were at length killed by adding to the spirit a quantity of corrosive sublimate."

The symptoms are much the same with those of the lumbrici, but more urgent.

M. M. See MATERIA MEDICA, section Anthelmintics.

Spasmodic Affections continued.

SECT. II. *In the vital Functions.*

Genus I. *Palpitatio*, palpitation. See Syncope.

Genus II. *Asthma.*

Symptoms. Difficult respiration returning at intervals, with a sense of tightness across the breast. Wheezing at the commencement of the asmatic fits; scarcely any cough but what is hard: towards the close of the paroxysm it however becomes more free, attended with a discharge of mucus.

These symptoms certainly arise from a spasmodic construction of the bronchial fibres, "which is communicated by consent to the larynx and diaphragm."

The causes of asthma are numerous, while its predisposition is often hereditary, and dependant upon a peculiar conformation and temperament; the actual disease may be excited by intemperance either in eating or

drinking, violent exercise, mental agitation, eruptions or discharges abruptly or unseasonably repelled; the fumes of metallic poison, as of lead, &c.

M. M. Spasmodic asthma, when fully established, scarcely admits of a radical cure. The paroxysms to be relieved by opium and æther; coffee; tonics in the intervals, principally of the class of bitters and aromatics. Avoid distending the stomach inordinately. Emetics; enemas previous to the expected accession; gentle horse exercise; pure air; oxygen gas. If eruptions have been repelled, endeavour to restore them.

Genus III. *Dyspnœa*, difficulty of breathing. This is improperly introduced into the nosology as a genus, it being merely a symptom of other diseases, consequent upon defective formation of the chest, or brought on by evident causes, which being removed, the disorder immediately declines.

Genus IV. *Pertussis*, hooping cough.

Symptoms. Convulsive strangulating cough, with noisy inspiration or hooping, and sometimes attended with vomiting. It is contagious.

The precise nature, or, as physicians express themselves, the proximate cause of hooping cough, does not seem to have been accurately ascertained. Dr. Darwin supposes it to be "an inflammation of the membranes which line the air-vessels of the lungs, and that it only differs from peripneunomia superficialis in the circumstance of its being contagious." He on this account enumerates it among the sensitive irritated fevers: we are inclined, however, to think that the infection principally operates upon the stomach; and that the inflammatory disorder of the mucous membrane is merely a consequence of the protraction, or erroneous treatment, of the complaint. It is not attended, in the first instance at least, with the symptoms of inflammatory irritation; and the vomiting, by which the violent fits are often relieved, proves that the stomach, in pertussis, is in a morbidly irritable state.

It deserves however to be remarked, that the membrane in question is very apt to partake of the prevailing irritation, to become inflamed, and thus, like the inflammation after small-pox, and measles more especially, to lay the foundation of consumption of the lungs.

M. M. Antimonial emetics. Very small doses. Warm bathing. Above all, digitalis; in no disease, perhaps, is the power of this valuable medicine displayed more forcibly and evidently than in hooping cough. Its effects are generally almost instantaneous. After the violence of the disease has subsided, and even before, change of air. Ciccuta (conium maculatum) has been much employed in this complaint.

Sect. III. *In the animal functions.*

Genus I. *Pyrosis.* Water-brash of Scotland. Waterqualm.

Symptoms. Sudden eructation of watery fluid with or without heartburn; the fluid brought from the stomach sometimes insipid.

M. M. The author of the present article recently had an opportunity of witnessing in this disease the beneficial effects of the inhalation of tobacco-smoke by a person not previously accustomed to smoking; this man had taken tonics, antispasmodics, and antacids, without effect. "A grain of opium twice a day, soap, iron powder, a blister." (Darwin.) Oxyd of bismuth the most effectual.

Genus II. *Calica*, colic.

Symptoms. Permanent and excrutiating pain in the belly, with a sensation as of twisting about the navel, constipation, and sometimes vomiting.

Causes. These symptoms evidently originate from spasmodic costriction in some part of the intestinal canal, which may be occasioned by various causes; such as indigestible food, the sudden application of cold; acrid substances received into the stomach; poisons, especially lead; hence colic is a kind of epidemic disease among painters, attended with paralysis of the arms, &c. It is likewise common in cyder countries.

M. M. Opium. Cathartics, principally of caster oil. Warm bathing. Anodyne clysters. Fometations and blisters to the part. In obstinate cases of the painters' colic, Bath waters, and repeated mecurial purges. Carefully obviate the exciting causes of the disease.

Genus III. *Cholera.*

Symptoms. Vomiting and purging of bilious matter, violent pains in the stomach and bowels, with great anxiety and irritability.

Cholera is one of the diseases of the autumnal months; it is very often produced by the sudden succession of cold to unusually warm weather: it sometimes follows the taking of indigestible substances, as of much cold cucumber, especially at the period of the year above-mentioned, when the directly debilitating power of cold abruptly succeeds to the indirectly debilitating operation of heat, and the biliary secretion is more than ordinarily copious.

M. M. During the violence of the vomiting and purging, give water-gruel, and inject starch clysters, to each of which add tincture of opium. After the disorder has in some measure subsided, have the bowels freely opened and restore due excitement by cordial and nourishing diet, with the stomachic medicines. If febrile irritation is induced, saline draught, composed of salt of wormwood and lemon-juice.

Genus IV. *Diarrhœa.*

Symptoms. Frequent stools, without primary pyrexia, and not induced by contagion.

A morbid action in the excretories of the intestines constitute this disease: sometimes however, and frequently, purging arises from mere loss of excitability in the intestinal fibre, without increase either of bile or any other excretion. It is immediately occasioned by acrid matter in the intestines; by acidities, by mental passions, or by the sudden application of cold, more especially to the feet.

M. M. According to the exciting causes. If there is reason to suspect the lodgment of acrid matter, calomel, with jalap, senna, or rhubarb. Afterwards astringents, of which one of the best is good red wine. Opium. Chalk, if acidity prevails. An emetic if the disorder continues obstinate.

Genus V. *Diabetes.*

Symptoms. Superabundant discharge of urine, in some cases amounting to fifty pounds in twenty-four hours, limpid and sweetish to the taste, with urgent and perpetual thirst, dry skin, weakness, emaciation.

This disease often, perhaps, exists to a very conside-

rable extent without being detected. It is not an uncommon complaint among the poor, especially of the north of Britain.

The principal circumstances that have attracted the notice of the pathologist in reference to this complaint, are the saccharine quality of the urine evacuated, and the attendant emaciation. One of the principal ingredients in the nutrition of the body has been supposed to be the saccharine principle; from the inordinate discharge of this principle in the diabetic urine, the disorder has been therefore referred by some to a deficiency of assimilating power in the stomach and digestive organs, while others have imagined it to originate entirely from altered action in the kidneys. Perhaps both of these causes may operate in producing diabetes. Upon dissection, the kidneys are always found flaccid. Dr. Darwin, after Mr. Charles Darwin, attributes the copious flow of urine to the inverted or retrograde action of the urinary lymphatics; but besides that this theory does not account for the superabundance of sugar or of mucilage in the water, it has been proved that such inversion of the absorbents is inconsistent with their structure and general economy.

M. M. Animal diet. Dr. Rollo and others have observed that when the patient lives on animal food, the saccharine quality of diabetic urine abates. Alkaline and astringent medicines, such as nut-galls and lime-water. Bark. Steel. Opium. Alum-whey.

N. B. A copious flow of urine is frequently observed to attend nervous affections, and indeed is one of the characteristics of the disease we are next to notice: in these cases however, the water has not the superabundance of the saccharine principle as in genuine diabetes, which last disorder has been erroneously placed in the class Neuroses.

Genus VI. *Hysteria.* The hysteric disease.

Symptoms. A gurgling of the bowels, followed by globus hystericus, or a sensation of a ball ascending to the throat, and menacing suffocation. Convulsive agitation, alternate laughing and crying, a general fickleness and irritability of mind. A large quantity of straw-coloured or limpid urine. Hysteria, like epilepsy, is in a certain degree extremely common; it generally first occurs in females about the time of puberty. It may be brought on by mental agitation, or by irritations in the stomach, bowels, uterine organs, &c.

The discharge of urine which attends or precedes hysteric paroxysm, is attributed by Dr. Darwin to the inverted motions of the lymphatics about the mouth of the bladder, as in diabetes; a temporary torpor, or spasm of these vessels, would appear sufficient to account for the superabundant excretion, the watery part of the urine not being taken up.

M. M. Avoid every occasional and exciting cause of the disease. Bark, quassia, and other tonics. To remove the present symptoms, camphor, assafœtida, castor, opium: if this last, from idiosyncracy, disagrees with the patient, the hyoscyamus will generally be found an excellent substitute. This has not the constipating tendency of opium; and in hysteric cases it is of importance, while much evacuation is guarded against, to preserve a freedom both in the alvine and cutaneous discharges. Emetics. N. B. The customary plan of bleeding in hysteric affections is extremely detrimental to the general health, and disposes to a return of the paroxysms. If it is judged necessary in some cases of hysteria to withdraw a small quantity of blood, it should be done not by venesection in the ordinary mode, but by the application of a cupping-glass.

Genus VII. *Hydrophobia.*

A dread of water as exciting painful convulsions of the pharynx, caused for the most part by the bite of a mad dog, violent spasms, furious insanity, death.

M. M. "When the contagion of a putrid fever is taken by the saliva into the stomach and bowels, which is its constant road," (query) "if the patient the moment he finds himself attacked with a sense of chilliness, loss of appetite, and an unpleasant taste in his mouth, has recourse to two emetics at proper intervals, and after the operation of the first emetic takes a cathartic, he has certainly got rid of the infection: in the same manner, even after three days, or perhaps a week, if the part bitten by the dog be cut out with the knife, the danger is escaped." (Townsend.) Dr. Thornton advised the application of hot vinegar, sharpened with vitriolic acid, to the wounds of five men who had been bitten by a rabid animal, and this application was attended with seeming success. Mercury: this by some has been extolled as a specific for hydrophobia.

Order IV. *Vesaniæ.*

Disorders of the intellect, independant of pyrexia or coma.

"Every nervous disease, (says an author whom we have before quoted) is a degree of insanity." If, however, imagination carried to the height of sentient perception, or, as it has been expressed by Dr. Batty, the raising up in the mind of images not distinguishable from impressions on the senses, is the proper definition of the insane state—"the cardinal point on which madness turns"—the above apophthegm of Dr. Reid may be regarded as rather bold and impressive than strictly accurate. It were surely improper to denominate the apoplectic, the paralytic, the hysteric, or the tetanic, insane; yet an individual under these maladies, is as truly affected with a nervous disorder as one who, like the lunatic astronomer in Rasselas, conceiting himself to possess the mastery of the elements, commands rain to shed fertility on the barren soil.

That the disorders of the intellect are disorders of the nerves we readily admit, it is the converse of the proposition we presume to question; and in so doing, we justify Dr. Cullen, in considering the vesaniæ, or mental affections, as a distinct order of nervous diseases.

The pathology of such diseases is peculiarly perplexing. We find by experience, that an increase of vascular action in a tender organ will give rise to the feeling of pain; we have ascertained by the conjunctive and mutually reflective aid of casual observation and direct experiment, that convulsive movements in the muscular fibre are occasioned by an interruption of nervous excitement in whatever that may consist; we see the brain pressed upon, and the apopletic stupor follow; but in endeavouring to trace deranged consciousness to disordered organization, temporary or permanent, an increase of intricacy appears in a manner to grow out of labour and research.

Dissection does not afford that assistance to the pathologist in this, as in many other departments of his inquiries; for, independantly of the great want of uniformity that has been observed in the brains of the unfortunate victims to mental derangement, it is impossible to judge from an inspection of this organ, how far the altered structures and appearances have been causes, and how far consequences, of the malady.

Dr. Cullen has four genera in his order vesaniæ, viz. amentia, melancholia, mania, and oneirodynia, on each of which we shall introduce a few remarks.

Genus I. *Amentia*, ideocy.

Amentia is defined an imbecility of judgment, preventing the perception or the recollection of the relations of things.

Man is born with merely a susceptibility of knowledge, a capacity of acquisition; he is conducted from observation to comparison, and from comparison to principle. Place an infant in a spacious apartment, give him for the first time the free use of all the senses with which nature has furnished him, and he will stretch out his hand to perhaps the most distant object in the room, with a full persuasion of being able to grasp it. Like the youth couched by Cheselden on Epsom Downs, every thing within the scope of his vision appears in a manner to touch his eye, he has not the smallest conception either of distance or magnitude, and the same total ignorance prevails in respect to objects which have relation to all his other senses. Knowledge then is the result of experience, which is another word for comparison or observation of "the relations of things."

As man, however, essentially differs from the brute, by the more extended compass of his intellectual grasp, the superinduction of the moral sense, and the anticipation of future events, so different individuals have varied susceptibilities of acquiring information; and this variation, which constitutes every shade of difference in intellectual character, must necessarily arise either from difference in the perceptive organs, or combining and retaining faculty. When then, without any apparent deficiency of the external senses, which are the inlets to knowledge, we find an individual not to have arrived at a given standard of intelligence by the constant employment of such senses, not to have obtained a due knowledge of "the relation of things," we place him out of the range of intelligent existences, have an obscure conception of something defective in the interior structure of his sentient organization; and denominate him an ideot.

This is the amentia congenita of Cullen, ideocy from birth.

Ideocy, however, may be produced. Fatuity may succeed to intellectual vigour, and the whole fabric of acquired knowledge be undermined and overthrown. Thus man may be literally reduced to the humiliating condition of second childhood. This state may be engendered abruptly and visibly, or gradually, and in almost in an imperceptible manner. It may follow violent agitations of the frame, as desolation succeeds to tempest, or may be brought about by the gradations of natural decay.

The causes of ideocy, when it is not the result of original malconformation, are, all kinds of intemperance, more especially indulgence in the use of spirituous liquors: "it has been traced up to somnolence too much indulged." The media through which it is principally occasioned are mania, apoplexy, and above all epilepsy. When firmly established even in youth, very little hope of recovery can be entertained by the friends of the unfortunate victim to his own imprudence. The condition of ideocy is a condition beyond the reach either of physical or moral influences!

Genus II. *Melancholia.*

Genus III. *Mania.*

We have placed these two genera of Dr. Cullen together, as we deem our author fundamentally erroneous in considering them distinct affections. Melancholia is defined "partial madness without dyspepsia." From this mode of reasoning, mania, instead of being distinguished by the character of universal madness, would have been with as much propriety denominated partial madness without fever.

Insanity is intensity of idea, converting imagination into implicit belief, and thus producing an incongruity of action; incongruity as it respects former, consistency as it relates to present, impressions and associations. It partakes of the character of mania or melancholia, of violent rage or gloomy despondency, according to the previous temperament of the sufferer, and the nature of the prevailing idea. In each the disordered associations are engendered upon precisely the same principles.

Madness differs from ideocy, as the conclusions derived from erroneous principles, in philosophising, differ from the conceptions of ignorance: the one is correct reasoning from erroneous premises, the other is defective judgment from defective information.

How this intensity of idea is produced, we have no means of ascertaining: we do not indeed feel it difficult to comprehend, that an absorbing attachment to one object, or an exclusive attention to one particular pursuit, may come at last to make shipwreck of the understanding; but it is the susceptibility of being carried away by this idea, that constitutes the difficulty of the question. Like the developement of intellectual character, the disposition to run into the state of insanity may perhaps depend upon the most minute circumstances of accidental associations: "Il ne faut qu'un leger accident, qu'un atome déplacé, pour te fair périr, pour te dégrader, pour te ravir cette intelligence dont tu parois si fier!" So precarious is the tenure, even of the most exalted possessions of man!

Madness, however, like ideocy, may be produced through the medium of bodily disorders; thus, fever will often occassion delirium, which is a species of temporary insanity. Thus, an obstruction of the menstrual discharge will frequently be the means of developing the latent disposition to maniacal disorder, occasioned by previous disease, resulting from erroneous education, or depending upon hereditary conformation. Indeed, almost the whole range of nervous diseases may, under predisposing circumstances, come to be exciting causes of genuine insanity. When lunacy has been brought on by bodily disorder, the complexion of the derangement shall be formed by the previous temperament, or natural disposition, of the sufferer; thus, the favourite ideas of health shall, in their increase, be the predominant and overwhelming ideas of madness; again, when the insane state has more

immediately proceeded from passions of the mind, or moral rather than physical causes, the idea that has vanquished the intellect shall continue to reign. The imaginary monarch shall preserve his dominions and sway, and through the medium of his distempered fancy, shall observe menials and attendants in the persons who surround him; the melancholy lover shall require but a female form to pass before his cell, to be persuaded of the actual presence of the object of his affections; and the religious enthusiast shall read a special embassy from heaven, in the countenance of every compassionate visitor.

Prognosis. "The chances of recovery are against those madmen, who can trace their indisposition to lunatic ancestry. When the causes are accidental, or obviously corporeal, a favourable termination may be expected. "The insanity subsequent to parturition, is generally curable if the curative attempts be rational." (Cox.) "Patients who are in a furious state recover in a larger proportion, than those who are depressed and melancholic. When the furious state is succeeded by melancholy, and after this shall have continued a short time the violent paroxysm returns, the hope of recovery is very slight. Indeed whenever these states of the diseased frequently change, such alteration may be considered as unfavourable. When insanity supervenes on epilepsy, or where the latter disease is induced by insanity, a cure is very seldom effected." (Haslam.) "When a person becomes insane who has a family of small children to solicit his attention, the prognostic is very unfavourable, as it shows the maniacal hallucination to be more powerful than those ideas that generally interest us the most." (Darwin.) "Though individuals of every temparament become insane, it has been observed that those of the sanguine more frequently recover."

M. M. Endeavour to draw off the mind from the prevailing idea, or otherwise to convince the maniac of the errors of his conceptions, and fallacy of his pretensions, by relating the incongruous conceits of other maniacs which have some affinity with his own. M. Pinel states, that in the Bicétre of Paris, a maniac was cured of the hallucination of supposing his head had been taken off by the guillotine, and that another had been placed on his shoulders, by a person judiciously ridiculing in his hearing the miracle of St. Dennis, who was said to carry his head under his arm, and to kiss it. When the maniac was endeavouring to prove the possibility of the fact by an appeal to his own case, the narrator of the story suddenly exclaims, "Why, how, you fool, could he kiss his own head? was it with his heel?" In incipient and equivocal madness, cautiously abstain from expressing suspicions in the hearing of the patient. "Nothing is more calculated to make a person mad than the idea of being thought so." (Reid.) On this account, premature confinement is to be deprecated, not merely as cruel, but as injudicious in the extreme. Those who are placed over the insane as guardians, should unite decision and firmness of character with tenderness of disposition and gentleness of manners.

In strong plethoric habits, venesection. Cathartics. These last, especially in melancholy, often require to be of the drastic kind, and united with calomel. "Diarrhœa very often proves a natural cure of insanity." (Haslam.) Vomits. Camphor. Opium in large doses. Cold bathing during the violence of the paroxysms, and in some cases warm bathing in the intervals. During the urgency of phrenzy, apply cold water to the head. Clay cap. Blisters to the scalp. In some cases the production of a vertiginous state by a rotatory swing, has lately been found effectual in breaking the morbid associations constituting phrenetic and melancholy paroxysms. Digitalis in very large doses, but regulated with care. Introducing a new disease, which is of a trivial nature, and easy of cure. "I should place considerable hopes on inoculation, had the party not had the small-pox, taking care by proper medicines and management, to increase the symptoms that usually attend this last disease to such a degree, that the whole system should be considerably affected without the life being endangered." (Cox.)

In instances where madness has originated from corporeal diseases, it scarcely requires to be observed, that a considerable part of the treatment must be constituted by the administration of those remedies that in common cases of these affections have been found to be effectual.

Genus IV. *Oneirodynia.* This genus is defined by Dr. Cullen "a violent and distressing imagination in time of sleep." It is divided into two species: the active, or that exciting to walking and various other motions; and the gravans, with a sense of weight or pressure on the chest. This last is the incubus of authors, or night-mare, which is doubtless placed erroneously among the disorders of the judgment.

The former of these is generally either congenital, or induced by unknown causes; it is perhaps principally curious, as it evinces the almost unlimited power of one sense, when concentrated as it were, or employed to the exclusion of the rest. Dr. Darwin relates the case of a gentleman who had lost his sight, entering his room, and immediately informing him of the length, breadth, and height of the apartment, by the undivided exercise of his sense of hearing; an accuracy which he could not have arrived at, had he retained the faculty of sight. In like manner the sleep-walker "will unlock his door, wander far from home, avoid opposing obstacles, and pass with safety over narrow bridges," which during his waking hours he would have shunned as unable to accomplish.

The incubus, or night-mare, appears to arise from an interruption of the circulation of blood through the lungs, from defective irritability in these organs, induced by fatigue, mental oppression, "a full supper, and wine;" which last, in some persons, will almost invariably induce the disease.

M. M. Temperance; especially moderate suppers. "To sleep on a hard bed with the head raised." Emetics. Purgatives of aloes and calomel. Tonics. Sleeping in a large airy apartment, and without curtains to the bed.

Class III. *Cachexiæ.* Cachexies.

Previously to an acquaintance with the distinct structure and separate functions of the nervous system, before the important discovery of the circulation of the blood, and the more recent, but hardly less important, developement of the anatomy and physiology of the secerning and absorbent vessels, the notions of pathologists on the mode in which disease, local and general, is occasioned, were indistinct and erroneous.

When, for example, on the surface of the body appeared a peculiar eruption, which after a certain time broke through the outer skin, and discharged an offensive matter, it was natural to infer that such discharge was engendered from a depraved condition of the solids or fluids of the living system, nearly in the same manner as exhalations proceed from dead and putrid animal or vegetable substance, or as wort is formed in the fermenting vat. Hence the use of the terms bad habit of body, foulness of blood, peccancy of humours, cachexies.

These gross and indiscriminate opinions respecting the actual nature and immediate cause of disease, are now retained alone by the vulgar; and as the nomenclature should keep pace with the advances of science, the word cachexy, as descriptive of those affections we are now to notice, ought to be banished from the phraseology of the nosologist; and a generic title substituted, indicative of disordered or deranged action in the secerning, absorbing, and glandular organs.

Order I. *Marcores.*

A wasting of the body or general emaciation.

Genus I. *Tabes.* Asthenia, emaciation, and hectic.

Genus II. *Atrophia.* Asthenia, and emaciation without hectic.

Dr. Cullen has properly distinguished the emaciation connected in its origin with hectic fever, from that independant of this as a primary and essential character. The latter, however, or atrophia. should not appear in the last class of diseases. When, for example, in consequence of mental affection, of sudden and too copious evacuation of any of the fluids, of deficiency in the quantity or depravation in the quality of the articles of diet, a loss of flesh and strength is perceived. the effect shall have been occasioned without any default in the absorbent vessels, and consequently without hectic; for let it be retained in the recollection, as a principle of the utmost importance in practice, that where hectic fever is present, a greater or less degree of derangement in the lymphatic vessels is likewise present. Hectic fever is a disease of the absorbent system.

For the purpose of illustrating this distinction between tabid and atrophic disorders, let two individuals be supposed equally emaciated and equally weak; but this weakness and emaciation in one shall have been induced by an indisposition to take a due quantity of nourishment, in order to supply the requisitions of the frame; in the other perhaps, notwithstanding the loss of bulk and of strength, an equal, or even greater quantity of aliment shall have been received into the stomach. Now, in this latter case, the tabid state has been occasioned by a torpid condition or improper action of those vessels whose office it is to separate the nutritive part of the food, and convey it, properly prepared, to the blood-vessels (see the article Digestion). In the former the mischief has proceeded from a want of those materials upon which these vessels exercise their functions. In the one the hectic flush from the very onset of the malady shall imprint the cheek; in the other, hectic will not be occasioned until the absorbents, from not being properly exercised, come at length to be disordered. The one complaint is the tabes of Dr. Cullen; the other is the atrophia of the same author.

We have been particular in pointing out this distinction, because it is not sufficiently noticed by writers in general, notwithstanding its extreme importance in practice; and because, by keeping it distinctly in view, we shall be enabled to reconcile the apparently contrary operation of those medicines which are employed with varied effect under different circumstances of debility and emaciation.

Steel, for instance, is one of those articles which, on account of their almost magic power over some diseases of debility, have been indiscriminately recommended in all; it has acquired the erroneous appellation of a tonic medicine, but as a tonic it often fails.

Now let us trace its effects in the two species of emaciation just alluded to. In the first stage of atrophy its administration will be often followed by irritative action, in the place of due excitement; the attendant febrile heat (not hectic fever) will be augmented, costiveness and an arid skin will follow, and indeed all the symptoms of the malady be heightened and confirmed.

In tabid diseases, on the other hand, the reverse effects will arise. Here the fever is hectic; and in the same degree that this valuable medicine, when duly employed, had increased the febrile irritation in atrophia, it will assuage the fever of tabes, and from the same cause, the stimulus which it imparts to the absorbent and lacteal vessels.

How hectic fever originates, it is difficult to explain: its symptoms have been attributed by a writer of the present day to that overplus of excitement being expended upon the arterial, which is occasioned by the deficient excitability of the absorbent system. This, however, is rather a statement than an explanation of its essence. The characteristics of hectic are principally the circumscribed redness on the cheek appearing more evidently once or twice in the course of the day, usually after meals, and alternating with a more than ordinary paleness of countenance; the pulse is feeble and quick; like the crimson flush of the cheek, it is accelerated by any thing received into the stomach; the urine is for the most part high-coloured, but deposits a bran-like sediment after standing for some time; the tongue is not furred in the same manner as in fever in general, but is clean; and often, as the disease advances, it increases in redness, the exact contrary to what is observed in genuine fever; the sweats are partial and irregular, and not attended with the same degree of temporary relief as in other cases; and, more especially in the advanced periods of the complaint, principally break out about the neck, breast, and shoulders; as the disease proceeds, debility and emaciation succeed, the legs and feet become œdematous, and (not however till nearly the fatal close of the malady on which the hectic depends) delirium at length supervenes.

M. M. In atrophia, a supply of nourishment, equivalent to the loss that may have been sustained: if emaciation has arisen from mental disturbance, the remedies must chiefly be made to apply to the mind. Tonics from the vegetable class, such as colombo, quassia, and gentian; not steel. Abate the febrile irritation. by keeping the bowels gently open by the milder purgatives, such as manna, senna, and castor oil. Preserve a slight moisture of the skin by small doses of antimonials. Regular and moderate, not violent or agitating, exercise. Shower-

bath in very warm, tepid bathing in cold weather. Pure air.

In tabes, or emaciation, accompanied by primary hectic. An emetic, to accomplish the double purpose of forcibly expelling ventricular and intestinal acidities, and exciting the languid absorbents. Drastic purgatives, as jalap or aloes, with calomel, with the same intention. Steel, in conjunction with Peruvian bark or bitters. Horse exercise. Warm bathing.

N. B. Tabes is for the most part symptomatic of other complaints, as of a disease of the lungs or the liver; and in such cases the treatment by which it is to be overcome is the treatment of the original or radical malady.

ORDER II. *Intumescentiæ, general swellings.*

Sect. I. *Adiposæ,* fatty swellings.

Genus I. *Polysarcia,* obesity. This arises from the deposition of oil in the adipose membrane becoming disproportionate to the requisitions of the body. It proceeds in general from indolence and intemperance.

M. M. Temperance, exercise, less animal food, early rising.

Sect. II. *Flatuosæ,* windy swellings.

Genus I. *Pneumatosis,* a tense elastic swelling of the body, crepitating under the touch.

Pneumatosis is constituted by a distention of the cellular membrane from air; it may arise without any evident cause, and in this case is denominated by Dr. Cullen the spontaneous pneumatosis; or the distending air may be introduced by means of an external wound, as of the thorax, in compound fracture of the ribs: sometimes elastic swellings of the whole body follow, from the application of poison; and at others, pneumatosis appears as an attendant upon the hysteric disorder.

The pathology of this disease, unless when it arises from wounds, is exceedingly obscure.

M. M. Scarifications, compresses, tonics.

Genus II. *Tympanites,* a windy swelling of the abdomen, tense, elastic, painful, and attended by costiveness.

Tympanitic swellings, both of the intestinal canal and of the cavity of the abdomen, often take place in conjunction with anasarca, or other disorders of debility, and frequently arise from sedentary habits, hypochondriac ailments, and innutritious diet.

M. M. Carminatives, emetics, tonics, and a generous diet, with exercise.

Tympanites is sometimes connected with obstructed menstruation, and in this case is seldom overcome but with the return of the menstrual discharge.

Genus III. *Physometra,* an elastic swelling in the hypogastrium, consequent upon flatulent distention of the womb.

"This frequently deceives the barren female with the hopes of pregnancy, till nature explains the mystery, and her expectations vanish in air."

Sect. III. *Aquosæ,* watery swellings.

Dropsical enlargement is distinguished from pneumatosis by its being inelastic, or pitting from the pressure of the finger, and slowly recovering its former fullness.

While considerable obscurity attends the nature and proximate cause of windy swellings, the theory of dropsical affections is sufficiently evident. Dropsy is a collection of serous fluid, either in the cellular membrane, or in the cavities of the body. It is invariably occasioned by exhalation being disproportionate to absorption; this increase of exhalation and diminution of absorption result from debility, which may be either direct or indirect; the latter follows increased action of the vessels, as in the dropsy succeeding to intemperance; the former arises out of deficient excitement in the lymphatic system; as when an individual becomes dropsical from indolence, inactivity, mental depression, and poverty of diet. Partial dropsies, or anasarcous swellings of the cellular membrane, as well as effusions into cavities, may also originate from pressure on the veins, independantly of original debility in the lymphatic vessels, such pressure obstructing the free reflux of blood through the venous system, and by consequence occasioning a more than ordinary determination to the exhalant arteries in the vicinity. Such are the dropsical accumulations which sometimes occur in pregnancy, and which are relieved by delivery. In this manner likewise, that swelling of the abdomen, constituting ascites, partly originates, when it is caused or attended by an obstructed circulation through the liver, the blood in the vena portæ accumulating in an inordinate measure, and by consequence supplying the lymphatic vessels of the part with more than their due proportion of fluid. Lastly, without universal debility in the exhalant and absorbent vessels, dropsical swellings may arise from inflammation, as is illustrated in the anasarcous collections following erysipelas, in the hydrocele succeeding to a blow on the testicle, in the dropsy of the chest resulting from inflammation of the lungs, and in ascites following peritoneal inflammation.

In whatever mode, and to whatever extent, dropsy may be occasioned, the accumulation of serous fluid by which it is constituted, always argues debility in the lymphatic vessels of the part in which this accumulation occurs. This debility, perhaps, is primarily and principally seated in the lymphatic exhalants; for we do not find hectic fever a characteristic of hydropic, as it is of other affections, in which an original torpor of the absorbents is evidently the cause of the morbid symptoms. Hectic only comes on in the last stages of dropsy, when the absorbents are worn out with constant exertion to absorb the effused fluid.

We have hitherto spoken indiscriminately of dropsy of cavities, and of dropsy in the cellular membrane: these, however, although they often exist conjointly, require to be distinguished; for instance, an accumulation of water in the thorax may be confined to the cellular texture of these organs, and form the disease properly distinguished by the denomination of anasarca pulmonum; or it may be diffused in the cavity of the chest, and constitute the true hydrops pectoris, or hydrothorax. The former generally arises from an universal torpor of the lymphatic system, and is almost constantly connected with hydropic swellings of other parts, particularly the ancles and legs; the latter often originates as a local disease, as from an inflammation of the pleura, and is sometimes confined entirely to the chest.

Genus I. *Anasarca.* General dropsy.

Dropsy of the cellular membrane immediately under the skin appears principally in the lower extremities, on account of the depending situation of these members, and

the universal connection between the cells of which the membrane is constituted; and party on account of the deficiency in lymphatic excitement, from which it originates, being more conspicuous in those vessels which are the furthest removed from the centre of the circulation. Anasarca, as it arises from exhausted excitability in the lymphatic vessels, is always a disorder indicating much danger.

M. M. Those stimuli which are found to exert their influence on the absorbent vessels, particularly steel, digitalis, calomel. Diuretics, such as squills, juniper, nitrous æther, cantharides, chrystals of tartar, and nitre. Emetics and cathartics are less proper in anasarca than in dropsy of cavities. The physician must be especially careful while evacuating the fluid by means of diuretics, to support the general excitement, in order to prevent its reaccumulation; from want of solicitous attention to this particular, the waters, after an apparent cure of anasarca, often again collect to an increasing extent. Punctures and scarifications of the extremities are seldom advisable, on account of the prevailing debility and tendency to gangrene.

The sparing use of liquids is generally proper in dropsy; instances, however, have been known of copious draughts of water producing a termination of the complaint.

Genus II. *Hydrocephalus*, dropsy of the brain. See INFANCY.

Genus III. *Hydrorachitis*, dropsical tumour in the spine. See SURGERY.

Genus IV. *Hydrothorax*, dropsy of the chest.

Symptoms. Difficulty of breathing, especially in a horizontal position, paleness of countenance, starting in sleep, palpitation of the heart, numbness of the arms, especially when elevated, and in the advanced stages of the malady an evident fluctuation of water in the cavity of the chest. The hydrothorax, or hydrops pectoris, "is distinguished from the anasarca pulmonum, as the patient in the former cannot lie down half a minute; in the latter, the difficulty of breathing, which occasions him to rise up, comes on more gradually; as the transition of the lymph in the cellular membrane, from one part to another of it, is slower than that of the effused lymph in the cavity of the chest." (Darwin.) We have already said, that in the anasarca pulmonum the disease is often attended with swelled legs. Dr. Darwin suspects that even this species of dropsy of the chest is in the greater number of instances a disease merely of the cellular membrane of the part, not of a general torpor of the lymphatic system, and that the legs do not swell till the patient, from the protraction of the local malady, becomes universally weak. We often, however, meet with ascitic and anasarcous swellings commencing in the extremities, which, in their course towards a fatal termination, rise up into the chest, and in this manner occasion the pulmonic affection. Here the general paralysis of the lymphatics precedes the primary disorder of the thorax.

Causes. Where the universal has preceded the local affection, the malady is most frequently to be traced to intemperance in the use of fermented and spirituous liquors. The most usual source of genuine hydrothorax, or hydrops pectoris, is the sudden application of cold, while the body is in a state of perspiration and debility, from previous heat and exercise. Young people, during perspiration and fatigue from dancing, "if they drink freely of cold lemonade or water are apt to bring on a dropsy of the chest." (Townsend.)

M. M. Digitalis in considerable doses is especially indicated in dropsy of the chest, and its effects are more visible as well as more certain in the anasarca pulmonum than in the hydrops pectoris, because this medicine influences powerfully the whole extent of the absorbent system. Squill, in combination with calomel, for the hydrops pectoris; and if the cellular membrane be anasarcous, connect steel with both the above medicines. Chrystals of tartar, especially in the anasarca pulmonum. Diuretics of other kinds, the same as in general anasarca. Opium. In hydrothorax, or dropsy of the chest, without anasarca, paracentesis, or puncture in the side. "It is sometimes impossible even to relieve the dropsy of intemperance; and the dropsical from this cause can never expect again to enjoy the pleasures of existence in full measure." (Beddoes.)

Genus V. *Ascites.* Dropsy of the abdomen.

The swelling of the abdomen is tense, scarcely elastic, but fluctuating; the fluctuation can sometimes be perceived by spreading one hand on one side of the abdomen, and striking with the other hand on the opposite side. Ascites is attended with scarcity of urine, thirst, and after some time a degree of hectic fever.

Ascites most usually originates through the medium of a diseased liver; and such disease, in the greater number of instances, itself induced by intemperance in spirituous liquors. Like the disease, however, of the lungs preceding dropsy in the chest, liver complaints productive of ascites, may be brought on by the precipitate application of cold succeeding to the extremes of heat, by indolence, mental affections, and other causes. Ascites sometimes originates from debility in the abdominal lymphatics, without the intervention of any hepatic disease.

M. M. Ascertain by inquiry into previous and present symptoms, whether any degree of liver complaint has preceded the dropsical accumulation; whether there is any disposition to jaundice of the skin; whether the alvine excretions are insufficient, whitish, and slimy; whether there has been any pain in the region of the liver, difficulty of lying on the side, especially on the left side, high colour of the urine, pain in the right shoulder, &c. and adapt the treatment accordingly. If the water is independant of disease in the liver, chrystals of tartar, digitalis, other diuretics, and steel, may be immediately had recourse to, without the intervention of calomel purgatives and of emetics, which last are almost always indicated in the more usual form of ascites, that form a morbid affection of the biliary organs. Emetics in hepatic ascites are often attended with most beneficial effects. "Per vomitus solvuntur cuncta tenacia, concutiuntur obstructa, expelluntur stagnantia, unde mirabiliter in hoc morbo prosunt." (Boerhaave.) In the administration of ascitic purgatives, care must be taken that, from the violence of excitement which they occasion, they do not induce peritoneal inflammation. A combination of gamboge, elaterium, and calomel, is frequently employed as a purgative in ascites. Mercurial ointment to the region of the liver. Tonics, especially steel. The

inhalatian of vital air, as recommended and employed by Dr. Thornton and others. Tapping. This is to be regarded in general as merely a palliative: if, however, there has not been any very considerable disease of the liver, or the debility is not extremely urgent, tapping may be advised with a prospect of effecting a radical cure, provided due care is at the same time employed to maintain a proper excitement, or, as it is generally expressed, to restore and preserve the tone of the system.

Genus V. *Hydrometria*. Dropsy of the womb.

This, like the physometra, already mentioned, often assumes a deceitful resemblance to pregnancy. It is characterized by dropsical swelling, confined to the region of the uterus, not being accompanied by other symptoms of dropsy.

It is a disease to which the unmarried and the barren are principally obnoxious; sometimes it follows abortion.

M. M. Stimulant fomentations. Drastic purgatives, and diuretics. Aromatic fœtid gums. Emmenagogues.

Genus VII. *Hydrocele*. Dropsy of the scrotum. See Surgery.

Sect. IV. *Solidæ*. Swellings of solid parts.

Genus I. *Physconia*. A swelling chiefly occupying a portion of the abdomen, increasing gradually, and neither tense nor sonorous as in pneumatosis, nor fluctuating as in dropsy.

This disease is principally formed by a schirrous state of the several parts, and viscera, which form its seat. These schirrous enlargements are generally incurable.

Genus II. *Rachitis*. Rickets. See Infancy.

Order III. *Impetigines*.

Deformities and discolourations of the external surface from general disease.

Genus I. *Scrophula*. King's evil.

Swellings of the lymphatic glands, terminating in ulcers, are perhaps the only proper characteristics of actual scrophula: the thick upper lip, transparent skin, and other appearances which are considered as symptoms of the disease, are merely marks of peculiar predisposition.

A scrophulous habit is merely a susceptibility of disease, arising from torpor in the lymphatic vessels, and when brought on by the agency of exciting causes, consists in a peculiar action of the lymphatic glands, by which inflammation and at length ulceration, with a discharge of grumous matter, are induced.

Its exciting causes are those which encourage the original debility, and the disease may almost certainly be avoided by attention to diet and regimen; by nutritious food, a pure oxygenous atmosphere, cleanliness, exercise, &c. See Infancy.

When by neglect, the predisposition has been permitted to break out into disease, calomel purges, steel, small doses of digitalis, warm and sea-bathing, muriates and phosphates of barytes? above all cleanliness; ventilation, stimulating nutritious diet. Let the mind be preserved free from the erroneous idea, that to cure scrophula is to purge away gross humours. See Surgery.

Genus II. *Syphilis*. Venereal disease.

After impure connection, a disorder of the genitals, ulcers in the mouth and nose. Eruptions on the skin of a copper colour, terminating in ulceration; these are principally situated near the margin of the hair; blotches on the surface of the body, especially on the surface of the face. Nocturnal pains in the centre of the bones.

M. M. Mercurials. Nitric acid. Tonics. N. B. For the local application to venereal ulcers, the more particular treatment of the complaint, and the mode of curing gonorrhea virulenta, see Surgery.

Genus III. *Scorbutus*, scurvy.

Indolence and lassitude: gloomy and tumid countenance; gums livid, and disposed to bleed spontaneously, or from the slightest irritation; skin dry, and covered with livid spots; œdematous swellings of the ancles. Scurvy appears to originate from want of, or exhausted excitement, both in the venous and absorbent system; it is produced by a protracted course of salt food, and by mental depression.

M. M. Fresh animal and vegetable diet. Juice of lemon. Bark. Steel. Terrene atmosphere. Mental excitement.

The elephantiasis, lepra, frambæsia, and trichoma, forming the fourth, fifth, sixth, and seventh genera of this order, are diseases of such rare occurrence in this country, as not to require any particular description.

For the more common eruptions which require local application, see Surgery.

Genus III. *Icterus*, jaundice.

Symptoms. Yellowness of the skin and eyes; white and slimy fæces; high-coloured urine, tinging linen yellow; langour, lassitude, and extreme depression of spirits.

The yellow colour of the skin, which constitutes jaundice, arises from the diffusion through the system of that bile, which, in the natural course, would pass through the biliary ducts into the intestinal canal. This impregnation of the system with bile has been supposed to be effected in three ways, viz. through the medium of the lacteal vessels and the thoracic duct, when the obstruction is in the duodenum; and by regurgitation through the hepatic veins, or absorption by the lymphatics of the liver, when the obstruction is in some part of the bile's course previous to its arrival in the duodenum.

This interruption of the biliary secretion may originate from a spasmodic affection near the duct; from chronic inflammations, or other diseases of the liver interfering with the secretion; from certain concretions lodging in some part of the hepatic organs, called gall-stones; and, as pointed out by Mr. Townsend, from viscid mucus stopping up or obstructing the biliary passages. Indeed, whatever hinders the bile from passing into the duodenum may prove a source of jaundice.

The first of the above species of jaundice is generally of a temporary nature; it occurs principally in those who have much irritability of habit, in consequence of violent passions, and other sources of spasmodic affections.

The second species is not of so decided a nature; it follows upon a long course of intemperance in spirituous liquors, and is only to be remedied by removing the disease of the liver itself.

The biliary calculi, which give rise to the third species of jaundice, appear, like urinary concretions, to arise from some defective action in the secretory or absorbing vessels of the parts in which they are formed or lodged; their production, like the stone in the bladder,

is evidently favoured by a retention of fluid, from which they are formed. It may therefore be inferred, the gall-stones are never, or seldom, produced without some previous jaundice having taken place. Thus they are both the cause and consequence of the disease. Their presence may be ascertained from jaundice frequently disappearing and returning, from the appearance of biliary concretions among the fæces, and from the disease being attended with shooting pains in the epigastric region, and right hypochondrium. Næusea, difficult respiration, and sickness, often likewise accompany this species of jaundice.

The icterus mucosus of Townsend, which is perhaps the most frequent species of jaundice, is unattended either by pain or spasmodic affections; there are no gall-stones observed in the fæces; but these are generally discharged mixed with much slime and viscidities. It is generally accompanied with, and indeed is most commonly occasioned by, a depression of mind, especially when favoured by sedentary habits, breathing an impure atmosphere, living upon unwholesome innutritious diet, or indulging in the too free use of "spirituous potation."

While it is the most frequent, and oftentimes the most protracted, of any of the species of jaundice, it is at the same time most easy of cure when properly understood and managed.

M. M. Emetics. Calomel purgatives. Bitter. Tonics, especially colombo, with rhubarb. Pure air. Exercise on horse back. Mental excitement.

In icterus spasmodicus, opium, assafœtida, æther, electricity. If the spasm depends upon any irritations in the stomach or bowels, these to be removed by emetics, purgatives, anthelmintics. In icterus calculosus, emetics to facilitate the passage of the gall-stones. Antispasmodics. Warm bathing. Emollient clysters. Vegetable tonics, and steel.

N. B. The average doses of medicines will be found stated in the articles MATERIA MEDICA, and PHARMACY.

MEDIETAS LINGUÆ, a jury or inquest impanelled, whereof the one-half consists of natives or denizens, the other strangers; and used in pleas wherein the one party is a stranger, the other a denizen.

MEDIUM, in logic, the mean or middle term of a syllogism, being an argument, reason, or consideration, for which we affirm or deny any thing; or, it is the cause why the greater extreme is affirmed or denied of the less in the conclusion.

MEDIUM, or MEAN, *geometrical*. See MEAN.

MEDULLA OBLONGATA. See ANATOMY.

MEDULLA SPINALIS. See ANATOMY.

MEDUSA, a genus of vermes of the order mollusca. The generic character is, body gelatinous, orbicular, and generally flat underneath: mouth central beneath. The animals of this genus consist of a tender gelatinous mass of different figures, furnished with arms or tentacular processes, proceeding from the lower surface: the larger species, when touched, cause a slight tingling and redness, and are usually denominated sea-nettles; they are supposed to constitute the chief food of cetaceous fish, and most of them shine with great splendour in the water. There are 44 species. See Plate LXXXIV. Nat. Hist. fig. 262.

MEIONITI, a mineral found only among the larva of Vesuvius, always crystallized. Primitive form, a prism whose bases are squares. It occurs usually in eight-sided prisms, and terminated by four-sided pyramids. Sometimes the edges of the prism are truncated. Colour greyish-white; fracture flat; melts before the blowpipe into a white spongy glass.

MELAMPODIUM, a genus of the class and order syngenesia polygamia necessaria. The calyx is five-leaved; recept. chaffy, conical; down one-leaved, involuted, converging. There are three species, herbs of the West Indies.

MELANITE, a mineral found in the neighbourhood of Vesuvius, and formerly called black garnet. Its colour is black or brownish. Crystallized in six-sided prisms, terminated by trihedral summits. It is composed of

40	silica
28.5	alumina
16.5	oxide of iron
10.0	magnesia
3.5	lime
0.25	oxide of magnesia.
98.75	

MELALEUCA, a genus of the polyandria order, belonging to the polyadelphia class of plants. The calyx is quinquepartite, superior; the corolla pentapetalous; the filaments are very numerous, and collected in such a manner as to form five pencils: there is one style; the capsule is half-covered with the calyx, formed like a berry, and is trivalved and trilocular. The species are 11, natives of India and the South Sea islands. The most remarkable species is the leucadendron, from a variety of which (the latifolia, or broad-leaved leucadendron) the cajeput oil is obtained; a medicine in very high esteem among the Eastern nations, particularly in India. It is said to be obtained by distillation from the fruit of the tree. When brought into this country it is a liquid of a greenish colour, of a fragrant but at the same time a very peculiar odour, and of a warm pungent taste. Some authors, however, represent this oil as being, when of the best quality, a white or colourless fluid; and it has been said by the authors of the Dispensatorium Brunsvicense, when prepared in Europe from the seeds sent from India, to be entirely of this appearance. Hitherto the oleum cajeput has been but little employed either in Britain or on the continent of Europe; but in India it is used both internally and externally, and is highly extolled for its medical properties. It is applied externally where a warm and peculiar stimulus is requisite: it is employed for restoring vigour after luxations and sprains, and for easing a violent pain in gouty and rheumatic cases, in tooth-ache, and similar affections; but it has been chiefly celebrated as taken internally, and it is particularly said to operate as a very powerful remedy against tympanic affections.

MELAMPYRUM, *cow-wheat*, a genus of the angiospermia order, in the didynamia class of plants, and in the natural method ranking under the 40th order, personatæ. The calyx is quadrifid; the upper lip of the corolla is compressed, with the edges folded back; the capsule is bilocular and oblique, opening at one side; there are two gibbous seeds. There are five species,

four of them natives of Britain, and growing spontaneously among corn-fields. They are excellent food for cattle; and Linnæus tells us, that where they abound, the yellowest and best butter is made. Their seeds, when mixed with bread, give it a dusky colour; and, according to some authors, produce a vertigo, and other disorders of the head; but this is denied by Mr. Withering, though he allows that they give it a bitter taste.

MELASTOMA, the *American gooseberry tree*, a genus of the monogynia order, in the decandria class of plants, and in the natural method ranking under the 17th order, calycanthemæ. The calyx is quinquefid and campanulated; the petals are five, inserted into the calyx; the berry is quinquelocular, and wrapped in the calyx. There are 67 species, most of them shrubs of the warm parts of America, and very beautiful on account of the variegation of their leaves. Most of the leaves are of two different colours on their surfaces; the under side being either white, gold-coloured, or russet, and the upper parts of different shades of green; so that they make a fine appearance in the hot-house all the year round. There are but few of these plants in the European gardens; which may, perhaps, have been occasioned by the difficulty of bringing over growing plants from the West Indies; and the seeds, being small when taken out from the pulp of their fruits, rarely succeed. Some of these species strike very easily from cuttings.

MELCHITES, in church history, the name given to the Syriac, Egyptian, and other christians of the Levant. They celebrate mass in the Arabian language. The religious, among the Melchites, follow the rules of St. Basil, the common rule of all the Greek monks. They have four fine convents, distant about a day's journey from Damas, and never go out of the cloister.

MELCHIZEDECHIANS, in church history, a sect which arose about the beginning of the third century, and affirmed, that Melchisedech was not a man, but a heavenly power, superior to Jesus Christ.

MELEAGRIS, in ornithology, the turkey, a genus of birds belonging to the order of gallinæ. The head is covered with spongy caruncles; and there is likewise a membranaceous longitudinal caruncle on the throat. There are but two species, viz. the gallopavo, or North American turkey of Ray; and the satyra, or horned turkey. The first has a caruncle both on the head and throat; and the breast of the male is bearded or tufted. It lives upon grain and insects; when the cock struts, he blows up his breast, spreads and erects his feathers, relaxes the caruncle on the forehead, and the naked parts of the face and neck become intensely red. Barbot informs us that very few turkeys are to be met with in Guinea, and those only in the hands of the chiefs of the European forts; the negroes declining to breed any on account of their tenderness, which sufficiently proves them not to be natives of that climate. He also remarks, that neither the common poultry nor ducks are natural to Guinea, any more than the turkey. Neither is that bird a native of Asia; the first that were seen in Persia were brought from Venice by some Armenian merchants. They are bred in Ceylon, but not found wild. In fact, the turkey, properly so called, was unknown to the ancient naturalists, and even to the old world, before the discovery of America; and with this the Portuguese name peru remarkably coincides. It was a bird peculiar to the new continent, and is now the commonest wild-fowl in the northern parts of that country, where they are frequently met with by hundreds in a flock; in the day-time they frequent the woods, where they feed on acorns, and return at night to the swamps to roost, which they do on the trees. They are frequently taken by means of dogs, though they run faster for a time; but the dogs persisting in the pursuit, the birds soon grow fatigued, and take to the highest tree, where they will suffer themselves to be shot one after another, if within reach of the marksman. This fowl was first seen in France in the reign of Francis I. and in England in that of Henry VIII. By the date of the reign of these monarchs, the first turkeys must have been brought from Mexico, the conquest of which was completed A. D. 1521.

The turkey hen begins to lay early in the spring, and will often produce a great number of eggs, which are white, marked with reddish or yellow spots, or rather freckles. She sits well, and is careful of her young; of which in this climate she will often have from 14 to 17 for one brood: but she scarcely ever sits more than once in a season, except allured thereto by putting fresh eggs under her as soon as the first set are hatched; for, as she is a close sitter, she will willingly remain two months on the nest, though this conduct, as may be supposed, is said greatly to injure the bird. Turkeys are bred in quantities in some of the eastern counties of England, and are driven up to London towards autumn for sale in flocks of several hundreds, which are collected from the several cottages about Norfolk, Suffolk, and neighbouring counties, the inhabitants of which think it well worth their while to attend carefully to them, by making these birds a part of their family during the breeding-season. It is pleasing to see with what facility the drivers manage them by means of a bit of red rag fastened to the end of a stick, which, from their antipathy to it as a colour, acts with the same effect as a scourge to a quadruped.

Of the turkey there are several varieties, which have arisen from domestication. The most common is dark-grey, inclining to black, or barred dusky-white and black. There is also a beautiful variety of a fine deep copper colour, with the greater quills pure white, and the tail of a dirty white; it is when old a most beautiful bird. A variety with a pure white plumage is also now not unfrequent, and appears very beautiful. It was once esteemed as a great rarity, and the breed supposed originally to have arisen in Holland. The sahjou inhabits India, and is sometimes less than the last. See Plate LXXXIV. Nat. Hist. fig. 261.

MELES, in zoology. See URSUS.

MELIA, *azarderach*, or the *bead-tree*, a genus of the monogynia order, in the decandria class of plants, and in the natural method ranking under the 23d order, trihilatæ. The calyx is quinquedentated; the petals five; the nectarium cylindrical, as long as the corolla, with its mouth ten-toothed; the fruit is a plum with a quinquelocular kernel. There are three species, all of them exotic trees of the Indies, rising near 20 feet high, adorned with large pinnated or winged leaves, and clusters of pentapetalous flowers. They are all propagated by seeds sown on hotbeds.

MELIANTHUS, *honey-flower*, a genus of the angiospermia order, in the didynamia class of plants, and in the natural method ranking under the 24th order, corydales. The calyx is pentaphyllous, with the lowermost leaf gibbous: there are four petals, with the nectarium under the lowest ones. The capsule is quadrilocular. There are three species: 1. The major has many upright, ligneous, durable stalks, and from the sides and tops of the stalks long spikes of chocolate-coloured flowers. 2. The minor has upright, ligneous, soft, durable stalks; and from the sides and ends of the branches long, loose, pendulous bunches of flowers tinged with green, saffron-colour, and red. Both the species flower about June; but rarely produce seeds in this country. They are very ornamental, both in foliage and flower, and merit admittance in every collection. They are easily propagated by suckers and cuttings. They thrive best in a dry soil, and in a sheltered warm exposure. 3. The common, little known.

MELICA, *ropegrass*, a genus of the digynia order, in the triandria class of plants, and in the natural method ranking under the 4th order, gramina. The calyx is bivalved, biflorous, with an embryo of a flower betwixt the two florets. There are three species, of which the most remarkable is the nutans. It is a native of several parts of Britain, and the adjacent islands; and the inhabitants of some of the western islands make ropes of it for fishing-nets, as it will bear the water for a long time without rotting.

MELICOCCA, a genus of the class and order octandria monogynia. The calyx is four-parted; the petals four, bent back; stigma subpeltate, drupe coriaceous. There is one species, a tree of South America.

MELICYTUS, a genus of the class and order dioecia pentandria. There is one species, of New Zealand, little known.

MELISSA, *baum*, a genus of the didynamia gymnospermia class of plants, with a monopetalous ringent flower, the lower lip of which is divided into three segments, whereof the middle one is cordated: the seeds are four in number, and contained in the bottom of the cup. There are six species.

Baum is greatly esteemed among the common people as good in disorders of the head and stomach; but is less regarded in the shops. It is most conveniently taken in infusion by way of tea; the green herb is greatly better than the dry, which is contrary to the general rule in relation to other plants.

MELITTIS, bastard baum, a genus of the didynamia gymnospermia class of plants; the upper lip of whose cup is emarginated; the upper lip of its flower is plane, and the lower one crenated. There are two species.

MELIUS INQUIRENDUM, in law, a writ that lies for a second inquiry to be made of what lands, &c. a man died seized; when partiality is suspected upon the writ diem clausit, &c.

MELLATS. This genus of salts is but imperfectly known, in consequence of the scarcity of mellitic acid. Hitherto they have been examined only by Klaproth and Vauquelin, and even by them too slightly to admit a description of their properties. The following are all the facts hitherto ascertained.

1. When mellitic acid is neutralized by potass, the solution chrystallizes in long prisms. The acid appears capable of combining with this salt, and forming a supermellat of potass. For when the mellite (or native mellat of alumina) is decomposed by carbonat of potass, and the alkaline solutions mixed with nitric acid, crystals are obtained consisting of mellitic acid combined with a small portion of potass.

2. When mellitic acid is neutralized by soda, the solution crystallizes in cubes, or three-sided tables; sometimes insulated, sometimes in groups.

3. When mellitic acid is saturated by ammonia, the solution yields fine transparent six-sided crystals, which become opaque when exposed to the air, and assume the white colour of silver.

4. When mellitic acid is dropt into barytes water, strontian water, or lime water, a white powder immediately precipitates, which is dissolved by adding a little more of the acid.

5. When the acid is mixed with a solution of sulphat of lime, very small gritty crystals precipitate, which do not destroy the transparency of the water; but the addition of a little ammonia renders the precipitate flaky. The precipitate produced by this acid in lime water is redissolved by the addition of nitric acid.

6. When this acid is dropt into acetat of barytes, a flaky precipitate appears, which is dissolved by adding more acid. With muriat of barytes it produces no precipitate; but in a short time a group of transparent needle-form crystals is deposited, consisting most likely of supermellat of barytes.

7. When this acid is dropt into sulphat of alumina, it throws down an abundant precipitate in the form of a white flaky powder.

MELLITE, *honeystone, mellat of alumina*. This mineral was first observed about 10 years ago in Thuringia, between the layers of wood coal. It is of a honey-yellow colour (whence its name); and is usually crystallized in small octahedrons, whose angles are often truncated. Fracture conchoidal. Specific gravity, according to Abich, 1.666. When heated it whitens, and in the open air burns without being sensibly charred. A white matter remains, which effervesces slightly with acids, and which at first has no taste, but at length leaves an acid impression upon the tongue.

Klaproth analysed the mellite in 1799, and ascertained it to be a compound of alumina and a peculiar acid, to which he gave the name of mellitic. And this analysis was soon after confirmed by M. Vauquelin.

MELLITIC ACID has been found only in the mellite. It may be procured from that mineral by the following process: Reduce the mellite to powder, and boil it in about 72 times its weight of water. The acid combines with the water, and the alumina separates in flakes. By filtering the solution, and evaporating sufficiently, the mellitic acid is obtained in the state of chrystals.

These crystals are either very fine needles, sometimes collected into globules, or small short prisms. They have a brownish colour, and a taste at first sweetish-sour, and afterwards bitterish.

This acid is not very soluble in water; but the precise degree of solubility has not been ascertained. When exposed to heat, it is readily decomposed, exhaling an abundant smoke, which however is destitute of smell. A

small quantity of insipid ashes remains behind, which do not alter the colour of litmus paper.

All attempts to convert it into oxalic acid by the action of nitric acid have failed. The nitric acid merely caused it to assume a straw-yellow colour.

The effect of the simple bodies on this acid has not been tried. It combines with alkalies, earths, and metallic oxides, and forms with them salts which are distinguished by the name of mellats. The properties of these compounds will be considered afterwards.

From the analysis of M. Klaproth, we learn that the mellite is composed of

46 mellitic acid
16 alumina
38 water

100.

From other analyses by the same chemist, he infers that mellitic acid is composed of carbon, hydrogen, and oxygen, but the proportions are not yet known.

MELOCHIA, *Jew's mallow*, a genus of the pentandria order, in the monadelphia class of plants, and in the natural method ranking under the 37th order, columniferæ. The capsule is quinquelocular and monospermous. There are 11 species: but the only remarkable one is the olitorius, or common Jew's-mallow, which is a native of the warm parts of Asia and America. It is an annual plant. The flowers sit close on the opposite side of the branches to the leaves, coming out singly; they are composed of five small yellow petals, and a great number of stamina surrounding the oblong germen, which is situated in the centre of the flower, and afterwards turns to a rough swelling capsule two inches long, ending in a point, and having four cells filled with angular greenish seeds. This species is cultivated about the city of Aleppo in Syria, and in the East Indies, as a pot-herb; the Jews boiling the leaves, and eating them with their meat.

MELODINUS, a genus of the class and order pentandria digynia. It is contorted; nect. in the middle of the tube, stellate; berry two-celled, many-seeded. There is one species, a shrub of New Caledonia.

MELODY, in music, the agreeable effect of different sounds, ranged and disposed in succession; so that melody is the effect of a single voice or instrument, by which it is distinguished from harmony.

MELOE, a genus of insects of the order coleoptera; the generic character is; antennæ moniliform, with the last joint ovate; thorax roundish; wing-sheaths soft, flexile; head inflected. Among the principal species of meloe may be numbered the meloe proscarabæus, commonly called the oil-beetle. It is of considerable size, often measuring near an inch and a half in length; its colour is violet-black, especially on the antennæ and limbs; the wing-sheaths are very short, in the female insect especially, scarcely covering more than a third of the body, and are of an oval shape. This species is frequent in the advanced state of spring in fields and pastures, creeping slowly, the body appearing so swoln or distended with eggs as to cause the insect to move with difficulty. On being handled it suddenly exsudes from the joints of its legs, as well as from some parts of the body, several small drops of a clear, deep-yellow oil or fluid, of a very peculiar and penetrating smell. This oil or fluid has been highly celebrated for its supposed efficacy in rheumatic pains, &c. when used as an embrocation on the parts affected; for this purpose also the oil expressed from the whole insect has been used with equal success. The female of this species deposits her eggs, which are very small and of an orange-colour, in a large heap or mass beneath the surface of the ground; each egg, when viewed by the microscope, appears of a cylindric shape, with rounded ends; from these are hatched the larvæ, which, at their first appearance, scarcely measure a line in length, and are of an ochre yellow, with black eyes; they are furnished with short antennæ, six legs of moderate length, and a long, jointed, tapering body, terminated by two forked filaments or processes. These larvæ are found to live by attaching themselves to other insects, and absorbing their juices. They are sometimes seen strongly fastened to common flies, &c. a practice so extraordinary as to have caused considerable doubt whether they could possible have been the real larvæ of the meloe proscarabæus. The accurate observations of Degeer, however, have completely proved that fact.

The meloe scabrosus extremely resembles the preceding, and is found in similar situations but differs in being of a reddish purple colour, with a cast of deep gilded green.

Meloe vesicatorius, blister-fly or Spanish fly, is an insect of great beauty, being entirely of the richest gilded grass-green, with black antennæ. Its shape is lengthened, and the abdomen, which is pointed, extends somewhat beyond the wing-sheaths; its usual length is about an inch. This celebrated insect, the cantharis of the materia medica, forms, as is well known, the safest and most efficacious epispatic, or blister-plaster; raising, after the space of a few hours, the cuticle, and causing a plentiful serous discharge from the skin. It is supposed however that the cantharis of Dioscorides, or that used by the ancients for the same purpose, was a different species, viz. the meloe cichorei of Linnæus, an insect nearly equal in size to the meloe proscarabæus, and of a black colour, with three transverse yellow bands on the wing-shells. The meloe vesicatorius is principally found in the warmer parts of Europe, as Spain, the south of France, &c. It is also observed, though far less plentifully, in some parts of Great Britain. See Plate LXXXIV. Nat. Hist. fig. 263.

MELON. See CUCUMIS.

MELOTHRIA, a genus of the monogynia order, in the triandria class of plants, and in the natural method ranking under the 34th order, cucurbitaceæ. The calyx is quinquefid; the corolla campanulated and monopetalous; the berry trilocular and monospermous. There is only one species, viz. the pendula, a native of Carolina, Virginia, and also many of the American islands. The plants strike out roots at every joint, which fasten themselves into the ground, by which means their stalks extend to a great distance each way. The flowers are very small, in shape like those of a melon, of a pale sulphur-colour. The fruit in the West Indies grows to the size of a pea, is of an oval figure, and changes to black when ripe; these are by the inhabitants sometimes pickled when they are green. In Britain the fruit are much smaller, and are so hidden by the leaves that it is diffi-

cult to find them. The plants are too tender to be reared in England without artificial heat.

MELYRIS, a genus of insects of the order coleoptera: the generic character is, antennæ entirely perfoliate; head inflected under the thorax; thorax margined; lip clavate, emarginate; jaw one-toothed, pointed. There are three species. See Plate LXXXIV. Nat. Hist. fig. 264.

MEMBRANE. See ANATOMY.

MEMECYLON, a genus of the octandria monogynia class and order. The calyx is superior; corolla one-petalled; anth. inserted in the side of the apex of the filament; berry crowned with cylindrical calyx. There are three species, trees of the East Indies.

MEMORY, *artificial*, a method of assisting the memory, by forming certain words, the letters of which shall signify the date or æra to be remembered. In order to this, the following series of vowels, diphthongs, and consonants, together with their corresponding numbers, must be exactly learned, so as to be able at pleasure to form a technical word, that shall stand for any number, or to resolve such a word already formed.

a	*e*	*i*	*o*	*u*	*au*	*oi*	*ei*	*ou*	*y*
1	2	3	4	5	6	7	8	9	0
b	*d*	*t*	*f*	*l*	*s*	*p*	*k*	*n*	*z*

The first five vowels, in order, naturally represent 1, 2, 3, 4, 5; the diphthong *au* = 6, as being composed of *a* and *u*, or 1 + 5 = 6; and for the like reason, *oi* = 7, and *ou* = 9. The diphthong *ei* will easily be remembered for 8, as being the initials of the word. In like manner, where the initial consonants could conveniently be retained, they are made use of to signify the number, as *t* for 3, *f* for 4, *s* for 6, and *n* for 9. The rest were assigned without any particular reason, unless that possibly *p* may be more easily remembered from 7 or septem, *k* for 8, or ὀκτω, *d* for 2, or duo; *b* for 1, as being the first consonant; and *l* for 5, being the Roman letter for 50; than any others that could have been put in their places.

It is farther to be observed, that *z* and *y* being made use of to represent the cypher, where many cyphers meet together, as 1000, 1000000, &c. instead of a repetition of *a z y z y z y*, &c. let *g* stand for 100, *th* for a thousand, and *m* for a million. Thus *ag* will be 100, *ig* 300, *oug* 900, &c. *ath* 1000, *am* 1000000, *loum* 59000000, &c.

Fractions may be set down in the following manner: let *r* signify the line separating the numerator and denominator, the first coming before, the other after it; as *iro* $\frac{3}{4}$, *urp* $\frac{5}{7}$, *pourag* $\frac{79}{100}$, &c. When the numerator is 1, or unit, it need not be expressed, but begin the fraction with *r*; as *re* $\frac{1}{2}$, *ri* $\frac{1}{3}$, *ro* $\frac{1}{4}$, &c. So in decimals, *rag* $\frac{1}{100}$, *rath* $\frac{1}{1000}$.

This is the principal part of the method, which consists in expressing numbers by artificial words. The application to history and chronology is also performed by artificial words. The art herein consists in making such a change in the ending of the name of a place, person, planet, coin, &c. without altering the beginning of it, as shall readily suggest the thing sought, at the same time that the beginning of the word being preserved, shall be a leading or prompting syllable to the ending of it so changed. Thus, in order to remember the years in which Cyrus, Alexander, and Julius Cæsar, founded their respective monarchies, the following words may be formed; for Cyrus, Cyr*uts*; for Alexander, Alex*ita*; for Julius Cæsar, Juli*os*. *Uts* signifies, according to the powers assigned to the letters before-mentioned, 536; *ita* is 331; and *os* is 46. Hence it will be easy to remember, that the empire of Cyrus was founded 536 years before Christ, that of Alexander 331, and that of Julius Cæsar 46. This account is taken from a treatise, entitled, a New Method of Artificial Memory; where the reader will find several examples in chronology, geography, &c. of such artificial words disposed in verses, which must be allowed to contribute much to the assistance of the memory, since being once learned, they are seldom or never forgotten. However, the author advises his reader to form the words and verses himself, in the manner described above, as he will probably remember these better than those formed by another.

We shall, in this place, give his table of the kings of England since the Conquest, where one thousand being added to the Italics in each word, expresses the year when they began their reigns. Thus,

Will con*sau*, Ruf*koi*, Heu*rag*
Steph*bil* & Hensec*buf*, Rich*bein*, J*ann*, Heth*das* & Ed*doid*.
Edse*typ*, Edter*tep*, Rise*tois*, Hefo*toun*, Hefi*sadque*.
Henfi*fed*, Edquar*fauz*, Efi-Ro*kt*, Hensep*feil*, Henoc*lyn*.
Edsex*los*, Mary*lut*, Els*luk*, Jams*yd*, Caropri*msel*.
Carsec*sok*, Jams*eif*, Wils*eik*, An*pyd*, Geo-*bo-doi*.

MENACHANITE. This substance has been found abundantly in the valley of Menachan in Cornwall; and hence was called menachanite by Mr. Gregor, the discoverer of it. It is in small grains like gunpowder, of no determinate shape, and mixed with a fine grey sand. Colour black. Easily pulverised. Powder attracted by the magnet. Specific gravity 4.427. Does not detonate with nitre. With two parts of fixed alkali it melts into an olive-coloured mass, from which nitric acid precipitates a white powder. The mineral acids only extract from it a little iron. Diluted sulphuric acid, mixed with the powder, in such a proportion that the mass is not too liquid, and then evaporated to dryness, produces a blue-coloured mass. Before the blowpipe does not decrepitate nor melt. It tinges microcosmic salt green; but the colour becomes brown on cooling; yet microcosmic salt does not dissolve it. Soluble in borax, and alters its colour in the same manner.

According to the analysis of Mr. Gregor, it is composed of

46 oxide of iron
45 oxide of titanium

91, with some silica and manganese.

According to M. Klaproth's analysis, it is composed of

51.00 oxide of iron
45.25 oxide of titanium
3.50 silica
.25 oxide of manganese.

100.00

Another variety of this ore from the Uralian mountains, analysed by Lowitz, contained

53 oxide of titanium
47 oxide of iron
——
100.

A mineral, nearly of the same nature with the one just described, has been found in Bavaria. Its specific gravity is only 3.7. According to the analysis of Vauquelin and Hecht, it is composed of

49 oxide of titanium
35 iron
2 manganese
14 oxygen combined with the iron and manganese
——
100.

A specimen of the same ore from Botany Bay has been lately analysed by Mr. Chenevix.

MENAIS, a genus of the pentandria monogynia class and order. The calyx is three-leaved; the corolla salver-shaped; berry four-celled; seeds solitary. There is one species, a herb of South America.

MENDICANTS, or begging friars, several orders of religious in popish countries, who, having no settled revenue, are supported by the charitable contribution they receive from others.

MENISCIUM, a genus of the cryptogamia filices. The capsules are heaped in crescents interposed between the veins of the pod. There is one species, a native of the West Indies.

MENISCUS. See OPTICS.

MENISPERMUM, a genus of the dioecia dodecandria class and order. The male petals are four outer, eight inner; stamina sixteen; female corolla, as in the male; stam. eight, barren; berries two, one-seeded. There are 13 species, herbs of the East Indies.

MENNONITES, a sect of baptists in Holland so called from Mennon Simonis of Friezland who lived in the sixteenth century. This sect believe that the New Testament is the only rule of faith; that the terms person and trinity are not to be used in speaking of the Father, Son, and Holy Ghost; that the first man was not created perfect; that it is unlawful to swear or to wage war upon any occasion; that infants are not the proper subjects of baptism; and that ministers of the gospel ought to receive no salary. They all unite in pleading for toleration in religion, and debar none from their assemblies who lead pious lives, and own the scriptures for the word of God.

MENSES. See PHYSIOLOGY.

MENSTRUUM, in chemistry, the fluid in which a solid body is dissolved. Thus water is a menstruum for salts, and gums; and alcohol for resins.

MENTHA, mint, a genus of the gymnospermia order, in the didynamia class of plants; and in the natural method ranking under the 42d order, verticillatæ. The corolla is nearly equal and quadrifid, with one segment broader than the rest, and emarginated; the stamina are erect, standing asunder. There are 19 species; but not more than three are cultivated for use, namely, the viridis, or common spearmint, the piperita or peppermint, and the pulegium or pennyroyal. All these are so well known as to need no description; and all of them are very easily propagated by cuttings, parting the roots, or by offsets.

For culinary purposes, the spearmint is preferred to the other two; but for medicine, the peppermint and pennyroyal have almost entirely superseded it. A conserve of the leaves is very grateful; and the distilled waters both simple and spirituous, are universally thought pleasant. Dr. Lewis says, that dry mint digested in rectified spirits of wine, gives out a tincture which appears by daylight of a fine dark-green, but by candle-light of a bright red colour. The fact is, that a small quantity of this tincture is green either by day-light or by candle-light, but a large quantity of it seems impervious to common day-light; however, when held betwixt the eye and a candle, or betwixt the eye and the sun, it appears red.

The virtues of mint are those of a warm stomachic, capable of relieving colicky pains, and the gripes, to which children are subject. It likewise proves an useful cordial in languors and faintness. When prepared with rectified spirit, the whole virtues of the mint are extracted. The expressed juice contains only the astringent and bitter parts, together with the mucilaginous substance common to all vegetables. The peppermint is much more pungent than the others.

Pennyroyal has the same general characters with the mint, but is more acrid and less agreeable when taken into the stomach. It was long held in great esteem in hysteric complaints, and suppressions of the menses, but its effects are trifling. It is observable, that both water and rectified spirit extract the virtues of this herb by infusion, and likewise elevate the greatest part of them by distillation.

MENTZELIA, a genus of the polyandria monogynia class and order. The cal. is five-leaved; cor. five-petalled; caps. inferior, cylindric, many-seeded. There is one species, an annual of South America.

MENYANTHUS, buckbean, a genus of the pentandria monogynia class of plants, with a monopetalous funnel-like flower, divided into five deep segments at the limb: the fruit is an oval capsule with one cell, containing a great many small seeds. There are five species.

Buckbean, called by authors trifolium palustre and paludosum, is greatly recommended as a diuretic in dropsical cases; as also in the cure of intermittent fevers, and disorders of the breast arising from tough matter in the lungs: the general way of taking it is in a strong infusion, though many prefer the juice fresh expressed from the leaves.

MERCATOR's *projection of maps*. See MAP.

MENSURATION, in general, denotes the act or art of measuring lines, superficies and solids; and it is, next to arithmetic, a subject of the greatest use and importance, both in affairs that are absolutely necessary in human life, and in every branch of mathematics; a subject by which sciences are established, and commerce is conducted; by whose aid we manage our business, and inform ourselves of the wonderful operations in nature; by which we measure the heavens and the earth, estimate the capacities of all vessels and the bulks of all bodies, gauge our liquors, build edifices, measure our lands and the works of artificers, buy and sell an infinite variety of things necessary in life, and are supplied with the means of making the calculations which are necessary for the construction of almost all machines.

It is evident that the close connection of this subject with the affairs of men would very early evince its importance to them; and accordingly the greatest among

them have paid the utmost attention to it; and the chief and most essential discoveries in geometry in all ages have been made in consequence of their efforts in this subject. Socrates thought that the prime use of geometry was to measure the ground, and indeed this business gave name to the subject; and most of the ancients seem to have had no other end beside mensuration in view in all their geometrical disquisitions. Euclid's Elements are almost entirely devoted to it; and although there are contained in them many properties of geometrical figures, which may be applied to other purposes, and indeed of which the moderns have made the most material uses in various disquisitions of exceedingly different kinds; notwithstanding this, Euclid himself seems to have adapted them entirely to this purpose: for, if it is considered that his Elements contain a continued chain of reasoning, and of truths, of which the former are successively applied to the discovery of the latter, one proposition depending on another, and the succeeding propositions still approximating towards some particular object near the end of each book; and when at the last we find that object to be the quality, proportion, or relation between the magnitudes of figures both plane and solid; it is scarcely possible to avoid allowing this to have been Euclid's grand object. Accordingly he determined the chief properties in the mensuration of rectilineal plane and solid figures; and squared all such planes, and cubed all such solids. The only curve figures which he attempted besides are the circle and sphere; and when he could not accurately determine their measures, he gave an excellent method of approximating to them, by showing how in a circle to inscribe a regular polygon which should not touch another circle, concentric with the former, although their circumferences should be ever so near together; and, in like manner, between any two concentric spheres to describe a polyhedron which should not any where touch the inner one: and approximations to their measures are all that have hitherto been given. But although he could not square the circle, nor cube the sphere, he determined the proportion of one circle to another, and of one sphere to another, as well as the proportions of all rectilineal similar figures to one another.

Archimedes took up mensuration where Euclid left it, and carried it a great length. He was the first who squared a curvilineal space, unless Hippocrates must be excepted on account of his lunes. In his times the conic sections were admitted in geometry, and he applied himself closely to the measuring of them as well as other figures. Accordingly he determined the relations of spheres, spheroids, and conoids, to cylinders and cones; and the relations of parabolas to rectilineal planes whose quadratures had long before been determined by Euclid. He has left us also his attempts upon the circle: he proved that a circle is equal to a right-angled triangle, whose base is equal to the circumference, and its altitude equal to the radius; and consequently that its area is found by drawing the radius into half the circumference; and so reduced the quadrature of the circle to the determination of the ratio of the diameter to the circumference; but which, however, has not yet been found. Being disappointed of the exact quadrature of the circle, for want of the rectification of its circumference, which all his methods would not effect, he proceeded to assign an useful approximation to it: this he effected by the numerical calculation of the perimeters of the inscribed and circumscribed polygons; from which calculations it appears that the perimeter of the circumscribed regular polygon of 192 sides is to the diameter, in a less ratio than that of $3\frac{1}{7}$ $(3\frac{10}{70})$ to 1, and that the inscribed polygon of 96 sides is to the diameter in a greater ratio than that of $3\frac{10}{71}$ to 1; and consequently much more than the circumference of the circle is to the diameter in a less ratio than that of $3\frac{1}{7}$ to 1, but greater than that of $3\frac{10}{71}$ to 1: the first ratio of $3\frac{1}{7}$ to 1, reduced to whole numbers, gives that of 22 to 7, for $3\frac{1}{7} : 1 :: 22 : 7$, which therefore will be nearly the ratio of the circumference to the diameter. From this ratio of the circumference to the diameter he computed the approximate area of the circle, and found it to be to the square of the diameter as 11 to 14. He likewise determined the relation between the circle and ellipse, with that of their similar parts. The hyperbola too, in all probability, he attempted; but it is not to be hoped, that he met with any success, since approximations to its area are all that can be given by all the methods that have since been invented.

Besides these figures, he has left us a treatise on the spiral described by a point moving uniformly along a right line, which at the same time moves with an uniform angular motion; and determined the proportion of its area to that of its circumscribed circle, as also the proportion of their sectors.

Throughout the whole works of this great man, which are chiefly on mensuration, he every where discovers the deepest design, and finest invention; and seems to have been (with Euclid) exceedingly careful of admitting into his demonstrations nothing but principles perfectly geometrical and unexceptionable: and although his most general method of demonstrating the relations of curved figures or straight ones, is by inscribing polygons in them, yet to determine those relations, he does not increase the number and diminish the magnitude of the sides ad infinitum; but from this plain fundamental principle, allowed in Euclid's Elements, viz. that any quantity may be so often multiplied, or added to itself, as that the result shall exceed any proposed finite quantity of the same kind, he proves that to deny his figures to have the proposed relations, would involve an absurdity.

He demonstrated also many properties, particularly in the parabola, by means of certain numerical progressions, whose terms are similar to the inscribed figures; but without considering such series to be continued ad infinitum, and then summing up the terms of such infinite series.

He had another very curious and singular contrivance for determining the measures of figures, in which he proceeds as it were mechanically by weighing them.

Several other eminent men among the ancients wrote upon this subject, both before and after Euclid and Archimedes; but their attempts were usually upon particular parts of it, and according to methods not essentially different from theirs. Among these are to be reckoned Thales, Anaxagoras, Pythagoras, Bryson, Antiphon, Hippocrates of Chios, Plato, Apollonius, Philo, and Ptolemy; most of whom wrote of the quadrature of the circle: and those after Archimedes, by this method,

usually extended the approximation to a greater degree of accuracy.

Many of the moderns have also prosecuted the same problem of the quadrature of the circle, after the same methods, to greater lengths: such are Vieta and Metius, whose proportion between the diameter and circumference is that of 113 to 355, which is within about $\frac{3}{10000000}$ of the true ratio; but above all Ludolph van Ceulen, woh, with an amazing degree of industry and patience, by the same ratio to 20 places of figures, making it that of 1 to 3.14159265358979323846 +. See CIRCLE.

Hence it appears, that all or most of the material improvements or inventions in the principles or methods of treating of geometry, have been made especially for the improvement of this chief part of it, mensuration, which abundantly shows the dignity of the subject; a subject which, as Dr. Barrow says, after mentioning some other things, "deserves to be more curiously weighed, because from hence a name is imposed upon that mother and mistress of the rest of the mathematical sciences, which is employed about magnitudes, and which is wont to be called geometry (a word taken from ancient use, because it was first applied only to measuring the earth, and fixing the limits of possessions): though the name seemed very ridiculous to Plato, who substitutes in its place the more extensive name of metrics or mensuration; and others after him give it the title of pantometry, because it teaches the method of measuring all kinds of magnitudes." See HEIGHTS, SURVEYING, LEVELLING, GEOMETRY, and GAUGING.

MERCURIALIS, mercury, a genus of the enneandria order, in the diœcia class of plants, and in the natural method ranking under the 38th order, tricoccæ. The calyx of the male is tripartite; there is no corolla, but 9 or 12 stamina; the antheræ globular and twin. The female calyx is tripartite; there is no corolla, but two styles; the capsule is bicoccous, bilocular, and monospermous. There are six species.

Of these, the perennis, according to Mr. Lightfoot, is of a soporific deleterious nature, noxious both to man and beast. There are instances of those who have eaten it by mistake, instead of the chenopodium bonus Henricus, or English mercury, and have thereby slept their last. Tournfort informs us, that the French make a syrup of the juice of the annua, another species, two ounces of which are given as a purge; and that they use it in pessaries and clysters, mixing one part of honey to one and a half of the juice. Dr. Withering differs greatly from Lightfoot concerning the qualities of the perennis. "This plant, (says he), dressed like spinach, is very good eating early in the spring, and is frequently gathered for that purpose; but it is said to be hurtful to sheep." Mr. Ray relates the case of a man, his wife, and three children, who experienced highly deleterious effects from eating it fried with bacon; but this was probably when the spring was more advanced, and the plant had become acrimonious. When steeped in water, it affords a fine deep-blue colour. Sheep and goats eat it; but cows and horses refuse it.

MERCURY, called also QUCKSILVER, was known in the remotest ages, and seems to have been employed by the ancients in gilding and in separating gold from other bodies, just as it is by the moderns.

Its colour is white, and similar to that of silver; hence the names hydrargyros, argentum vivum, quicksilver, by which it has been known in all ages. It has no taste nor smell. It possesses a good deal of brilliancy; and when its surface is not tarnished, makes a very good mirror. Its specific gravity is 13.568. At the common temperature of the atmosphere, it is always in a state of fluidity. In this respect it differs from all other metals. But it becomes solid when exposed to a sufficient degree of cold. The temperature necessary for freezing this metal is —39°, as was ascertained by the experiments of Mr. Macnab at Hudson's-bay. The congelation of mercury was accidentally discovered by the Petersburgh academicians in 1759. Taking the advantage of a very severe frost, they plunged a thermometer into a mixture of snow and salt, in order to ascertain the degree of cold. Observing the mercury stationary, even after it was removed from the mixture, they broke the bulb of the thermometer, and found the metal frozen into a solid mass. This experiment has been repeated very often since, especially in Britain. Mercury contracts considerably at the instant of freezing; a circumstance which mislead the philosophers who first witnessed its congelation. The mercury in their thermometers sunk so much before it froze, that they thought the cold to which it had been exposed, much greater than it really was. It was in consequence of the rules laid down by Mr. Cavendish, that Mr. Macnab was enabled to ascertain the real freezing point of the metal.

Solid mercury may be subjected to the blows of a hammer, and may be extended without breaking. It is therefore malleable; but neither the degree of its malleability, nor its ductility, nor its tenacity, has been ascertained.

Mercury boils when heated to 660°. It may therefore be totally evaporated, or distilled from one vessel into another. It is by distillation that mercury is purified from various metallic bodies, with which it is often contaminated. The vapour of mercury is invisible and elastic like common air; like air, too, its elasticity is indefinitely increased by heat, so that it breaks through the strongest vessel. Geoffroy, at the desire of an alchymist, inclosed a quantity of it in an iron globe, strongly secured by iron hoops, and put the apparatus into a furnace. Soon after the globe became red-hot, it burst with all the violence of a bomb, and the whole of the mercury was dissipated.

Mercury is not altered by being kept under water. When exposed to the air, its surface is gradually tarnished, and covered with a black powder, owing to its combining with the oxygen of the atmosphere. But this change goes on very slowly, unless the mercury is either heated or agitated, by shaking it, for instance, in a large bottle full of air. By either of these processes, the metal is converted into an oxide: by the last, into a black-coloured oxide; and by the first, into a red-coloured oxide. This metal does not seem to be capable of combustion.

The oxides of mercury at present known are four in number:

1. The protoxide was first described with accuracy by Boerhaave. He formed it by putting a little mercury into a bottle, and tying it to the spoke of a mill-wheel. By the constant agitation which it thus underwent, it

was converted into a black powder, to which he gave the name of *ethiops per se.* The oxide is readily formed by agitating impure mercury in a phial. It is a black powder without any of the metallic lustre, has no taste, and is insoluble in water. According to the experiments of Fourcroy, it is composed of 96 parts of mercury and 4 of oxygen. When this oxide is exposed to a strong heat, oxygen gas is emitted, and the mercury reduced to the metallic state. In a more moderate heat it combines with an additional dose of oxygen, and assumes a red colour.

2. When mercury is dissolved in nitric acid without the assistance of heat, and the acid is made to take up as much mercury as possible, it has been demonstrated, by the experiments of Mr. Chenevix, that it combines in that case with 10.7 per cent. of oxygen. Of course an oxide is formed, composed of 89.3 mercury and 10.7 oxygen. This is the deutoxide of mercury. This oxide cannot be separated completely from the acid which holds it in solution without undergoing a change in its composition; of course we are at present ignorant of its colour and other properties. Indeed it is very probable that it is the same with the black oxide just described under the name of protoxide; but this has not yet been proved in a satisfactory manner.

3. When mercury, or its protoxide, is exposed to a heat of about 600°, it combines with additional oxygen, assumes a red colour, and is converted into an oxide, which, in the present state of our knowledge, we must consider as a tritoxide. This oxide may be found two different ways: 1. By putting a little mercury into a flat bottomed glass bottle or matrass, the neck of which is drawn out into a very narrow tube, putting the mattrass into a sand bath, and keeping it constantly at the boiling point. The height of the mattrass, and the smallness of its mouth, prevent the mercury from making its escape, while it affords free access to the air. The surface of the mercury becomes gradually black, and then red, by combining with the oxygen of the air: and at the end of several months the whole is converted into a red powder, or rather into small crystals, of a very deep red colour. The oxide, when thus obtained, was formerly called precipitate per se. 2. When mercury is dissolved in nitric acid, evaporated to dryness, and then exposed to a pretty strong heat in a porcelain cup, it assumes, when triturated, a brilliant red colour. The powder thus obtained was formerly called red precipitate, and possesses exactly the properties of the oxide obtained by the former process.

This oxide has an acrid and disagreeable taste, possessing poisonous qualities, and acts as an escharotic when applied to any part of the skin. It is somewhat soluble in water. When triturated with mercury it gives out part of its oxygen, and the whole mixture is converted into protoxide or black oxide of mercury. When heated along with zinc, or tin filings, it sets the metals on fire. According to Fourcroy, it is composed of 92 parts of mercury and 8 of oxygen. But the analysis of Mr. Chenevix, to be described hereafter, gives, for the proportion of its component parts, 85 parts of mercury and 15 parts of oxygen.

The red oxide of mercury, prepared in the usual way, is not pure, but always contains a portion of nitric acid. If we dissolve it in muriatic acid, and precipitate it again, it falls in the state of a white powder, and retains a portion of muriatic acid. It was in this state that it was examined by Chenevix. The difficulty of procuring this oxide in a state of purity, and the uncertainty respecting the proportion of acid which it retains, may, in some measure, account for the different results obtained by different chemists in their attempts to ascertain its proportions.

4. Fourcroy has observed, that when oxymuriatic acid gas is made to pass through the red oxide of mercury, it combines with an additional dose of oxygen, and is converted into a peroxide; but as this peroxide cannot be procured in a separate state, we are ignorant of its properties:

Mercury does not combine with carbon or hydrogen; but it unites readily with sulphur and with phosphorus.

When two parts of sulphur and one of mercury are triturated together in a mortar, the mercury gradually disappears, and the whole assumes the form of a black powder, formerly called ethiops mineral. It is scarcely possible by any process to combine the sulphur and mercury so completely, that small globules of the metal may not be detected by a microscope. When mercury is added slowly to its own weight of melted sulphur, and the mixture is constantly stirred, the same black compound is formed.

Fourcroy had suggested, that in this compound the mercury is in the state of black oxide, absorbing the necessary proportion of oxygen from the atmosphere during its combination with the sulphur. But the late experiments of Proust have shown that this is not the case. Berthollet has made it probable that ethiops mineral contains sulphureted hydrogen. Hence we must consider it as composed of three ingredients, namely, mercury, sulphur, and sulphureted hydrogen. Such compounds are at present denominated by chemists hydrogenous sulphurets. Ethiops mineral of course is an hydrogenous sulphuret of mercury. When this substance is heated, part of the sulphur is dissipated, and the compound assumes a deep violet colour.

When heated red-hot, it sublimes; and if a proper vessel is placed to receive it, a cake is obtained of a fine red colour. This cake was formerly called cinnabar; and when reduced to a fine powder, it is well known in commerce under the name of vermilion. It has been hitherto supposed a compound of the oxide of mercury and sulphur. But the experiments of Proust have demonstrated that the mercury which it contains is in the metallic state. According to that very accurate chemist, it is composed of 85 parts of mercury and 15 of sulphur. It is therefore sulphuret of mercury.

The sulphuret of mercury has a scarlet colour, more or less beautiful, according to the mode of preparing it. Its specific gravity is about 10. It is tasteless, insoluble in water, and in muriatic acid, and not altered by exposure to the air. When heated sufficiently, it takes fire, and burns with a blue flame. When mixed with half its weight of iron filings, and distilled in a stone-ware retort, the sulphur combines with the iron, and the mercury passes into the receiver, which ought to contain water. By this process mercury may be obtained in a state of puri-

ty. The use of sulphuret of mercury as a paint is well known.

Mr. Pelletier, after several unsuccessful attempts to combine phosphorus and mercury, at last succeeded by distilling a mixture of red oxide of mercury and phosphorus. Part of the phosphorus combined with the oxygen of the oxide, and was converted into an acid; the rest combined with the mercury. He observed that the mercury was converted into a black powder before it combined with the phosphorus. As Pelletier could not succeed in his attempts to combine phosphorus with mercury in its metallic state, we must conclude that it is not with mercury, but with the black oxide of mercury, that the phosphorus combines. The compound, therefore, is not phosphorus of mercury, but black phosphureted oxide of mercury.

It is of a black colour, of a pretty solid consistence, and capable of being cut with a knife. When exposed to the air, it exhales vapours of phosphorus.

Mercury does not combine with the simple incombustibles.

Mercury combines with the greater number of metals. These combinations are known in chemistry by the name of amalgams.

The amalgam of gold is formed very readily, because there is a very strong affinity between the two metals. If a bit of gold is dipped into mercury, its surface, by combining with mercury, becomes as white as silver. The easiest way of forming this amalgam is to throw small pieces of red-hot gold into mercury. The proportions of the ingredients are not determinable, because the amalgam has an affinity both for the gold and the mercury; in consequence of which they combine in any proportion. This amalgam is white, with a shade of yellow; and when composed of six parts of mercury and one of gold, it may be obtained crystallized in four-sided prisms. It melts at a moderate temperature; and when heated sufficiently, the mercury evaporates, and leaves the gold in a state of purity. It is much used in gilding. The amalgam composed of ten parts of mercury and one of gold, is spread upon the metal which is to be gilt; and then, by the application of a gentle and equal heat, the mercury is driven off, and the gold left adhering to the metallic surface is then rubbed with a brass-wire brush under water, and afterwards burnished.

Dr. Lewis attempted to form an amalgam of platinum, but hardly succeeded after a labour which lasted for several weeks. Guyton Morveau succeeded by means of heat. He fixed a small cylinder of platinum at the bottom of a tall glass vessel, and covered it with mercury. The vessel was then placed in a sand-bath, and the mercury kept constantly boiling. The mercury gradually combined with the platinum; the weight of the cylinder was doubled, and it became brittle. When heated strongly, the mercury evaporated, and left the platinum partly oxidated. It is remarkable, that the platinum, notwithstanding its superior specific gravity, always swam upon the surface of the mercury, so that Morveau was under the necessity of fixing it down.

The amalgam of silver is made in the same manner as that of gold, and with equal ease. It forms dentritical crystals, which, according to the Dijon academicians, contain eight parts of mercury and one of silver. It is of a white colour, and is always of a soft consistence. Its specific gravity is greater than the mean of the two metals. Gellert has even remarked that, when thrown into pure mercury, it sinks to the bottom of that liquid. When heated sufficiently, the mercury is volatilized, and the silver remains behind pure.

The affinities of mercury as ascertained by Morveau, and of its oxides as exhibited by Bergman, are in the following order:

Mercury.	Oxide of Mercury.
Gold,	Muriatic acid,
Silver,	Oxalic,
Tin,	Succinic,
Lead,	Arsenic,
Bismuth,	Phosphoric,
Platinum,	Sulphuric,
Zinc,	Saclactic,
Copper,	Tartaric,
Antimony,	Citric,
Arsenic,	Sulphurous,
Iron,	Nitric,
	Fluoric,
	Acetic,
	Boracic,
	Prussic,
	Carbonic.

Mercury, in astronomy, the smallest of the planets, and the nearest the sun. See Astronomy.

MERGUS, in ornithology, a genus of birds of the order of anseres; distinguished by having the beak of a cylindrical figure, and hooked at the extremities, and its denticulations of a subulated form.

1. The calcullatus, or crested diver of Catesby, has a globular crest, white on each side; and the body is brown above, and white below. This elegant species inhabits North America. It appears at Hudson's-bay the end of May, and builds close to the lakes. The nest is composed of grass, lined with feathers from the breast; the number of eggs from four to six. The young are yellow, and are fit to fly in July. They all depart from thence in autumn. They appear at New York, and other parts, as low as Virginia and Carolina, in November, where they frequent fresh waters. They return to the north in March, and are called at Hudson's-bay omiska sheep. See Plate XCI. Nat. Hist. fig. 265.

2. The merganser, or goosander, weighs four pounds; its length is two feet four inches: the breadth three feet four. The dun-diver, or female, is less than the male; the head and upper part of the neck are ferruginous; the throat white; the feathers on the hind part are long, and form a pendant crest; the back, the coverts of the wings, and the tail, are of a deep ash-colour; the greater quill-feathers are black, the lesser white; the breast and middle of the belly are white, tinged with yellow. The goosander seems to prefer the more northern situations to those of the south, not being seen in the last except in very severe seasons. It continues the whole year in the Orkneys; and has been shot in the Hebrides in summer. It is common on the continent of Europe and Asia, but most so towards the north.

3. The albellus, or smew, weighs about 34 ounces; the length is 18 inches, the breadth 26; the bill is near two inches long, and of a lead-colour; the head is adorned

with a long crest, white above and black beneath; the head, neck, and whole under part of the body, are of a pure white; the tail is of a deep ash-colour, the legs a bluish grey. The female, or lough-diver, is less than the male; the back, the scapulars, and the tail, are dusky; the belly is white. The smew is seen in England only in winter, at which season it will sometimes be met with at the southern parts of it; as also in France, in the neighbourhood of Picardy, where it is called la piette: similar to this, we have heard it called in Kent by the name of magpie-diver.

There are three other species.

MERIDIAN. See ASTRONOMY and GEOGRAPHY.

MERIDIONAL PARTS, MILES, or MINUTES, in navigation, are the parts by which the meridians in Mr. Wright's chart (commonly though falsely called Mercator's) increase as the parallels of latitude decrease: and as the cosine of the latitude of any place is equal to the radius or semi-diameter of that parallel, therefore, in the true sea-chart, or nautical planisphere, this radius being the radius of the equinoctial, or whole sine of 90°, the meridional parts at each degree of latitude must increase, as the secants of the arch, contained between that latitude and the equinoctial, do decrease. The tables therefore of meridional parts, which we have in books of navigation, are made by a continual addition of secants; they are calculated in some books for every degree and minute of latitude; and they will serve either to make or graduate a Mercator's chart, or to work the Mercator's sailing. To use them, you must enter the table with the degree of latitude at the head, and the minute on the first column towards the left hand, and in the angle of meeting you will have the meridional parts. Having the latitudes of two places, to find the meridional miles or minutes between them: Consider whether one of the places lies on the equator, or both on the same side of it; or, lastly, on different sides. 1. If one of the proposed places lies on the equator, then the meridional difference of latitude is the same with the latitude of the other place, taken from the table of meridional parts. 2. If the two proposed places be on the same side of the equator, then the meridional difference of latitude is found by subtracting the meridional parts answering to the least latitude, from those answering to the greatest, and the difference is that required. 3. If the places lie on different sides of the equator, then the meridional difference of latitude is found by adding together the meridional parts answering to each latitude, and the sum is that required.

To find the MERIDIONAL PARTS *to any Spheroid, with the same exactness as in a Sphere.* Let the semidiameter of the equator be to the distance of the centre from the focus of the generating ellipse, as m to 1. Let A represent the latitude for which the meridional parts are required, s the sine of the latitude, to the radius 1 : find the arc B, whose sine is $\frac{s}{m}$; take the logarithmic tangent of half the complement of B, from the common tables; subtract the log. tangent from 10.0000000, or the log. tangent of 45°; multiply the remainder by the number 7915.7044679, and divide the product by m: then the quotient subtracted from the meridional parts in the sphere, computed in the usual manner for the latitude A, will give the meridional parts, expressed in the minutes, for the same latitude in the spheroid, when it is the oblate one.

Example. If $mm : 1 :: 1000 : 22$, then the greatest difference of the meridional parts in the sphere and spheroid is 76.0929 minutes. In other cases it is found by multiplying the remainder above-mentioned by the number 1174.078.

When the spheroid is oblong, the difference in the meridional parts between the sphere and spheroid, for the same latitude, is then determined by a circular arc.

We shall here add a table of meridional parts, calculated both for the sphere and oblate spheroid, by the reverend Mr. Murdoch, in his new and learned Treatise of Mercator's Sailing applied to the true Figure of the Earth. By this table may be projected a true chart for any part of the earth's surface, and the several problems of sailing may be solved by it. Maps of countries may be delineated and applied to the various purposes of navigation, geography, and astronomy. Nor are the errors of the common spherical projections so very small in many cases, as to be inconsiderable and not dangerous. For instance, if a ship sails from south latitude 25°, to north latitude 30°, and the angle of the course be 43°: then the difference of longitude by the common table would be 3206′, exceeding the true difference 3141′ by 65′, or miles. Also the distance sailed would be 4512, exceeding the true distance, 4423, by 89′, or miles, which differences are too great to be neglected. For other instances of such a correction of the charts, we refer to the author's admirable book above-mentioned.

A TABLE

Of Meridional Parts to the Spheroid and Sphere, with their differences.

D.	Spheroid	Sphere	Diff.
1	58.7	60.0	1.3
2	117.3	120.0	2.7
3	176.1	180.1	4.0
4	234.9	240.2	5.3
5	293.8	300.4	6.6
6	352.7	360.6	7.9
7	411.8	421.0	9.2
8	471.0	481.5	10.5
9	530.4	542.2	11.8
10	589.9	603.0	13.1
11	649.7	664.1	14.4
12	709.6	725.3	15.7
13	769.3	786.8	17.0
14	830.2	848.5	18.3
15	890.9	910.5	19.6
16	951.8	972.7	20.9
17	1013.1	1035.3	22.2
18	1074.8	1098.3	23.5
19	1136.8	1161.6	24.8
20	1199.2	1225.2	26.0
21	1262.0	1289.2	27.2
22	1325.3	1353.7	28.4
23	1389.0	1418.6	29.6
24	1453.3	1484.1	30.8
25	1518.0	1550.0	32.0
26	1583.3	1616.5	33.2
27	1649.1	1683.5	34.4
28	1715.6	1751.2	35.6

D.	Spheroid	Sphere.	Diff.
29	1782.7	1819.5	36.8
30	1850.5	1888.4	37.9
31	1919.0	1958.0	39.0
32	1988.2	2028.3	40.1
33	2058.3	2099.5	41.2
34	2129.0	2171.4	42.3
35	2200.8	2244.2	43.4
36	2273.4	2317.9	44.5
37	2347.0	2392.6	45.6
38	2421.6	2468.3	46.7
39	2497.2	2544.9	47.7
40	2573.9	2622.6	48.7
41	2651.8	2701.5	49.7
42	2730.9	2781.6	50.7
43	2811.3	2863.0	51.7
44	2893.1	2945.8	52.7
45	2976.2	3029.9	53.7
46	3060.9	3115.5	54.6
47	3147.2	3202.7	55.5
48	3235.1	3291.5	56.4
49	3324.8	3382.1	57.3
50	3416.3	3474.5	58.2
51	3509.7	3568.8	59.1
52	3605.3	3665.2	59.9
53	3703.1	3763.8	60.7
54	3803.1	3864.6	61.5
55	3905.7	3968.0	62.3
56	4010.9	4073.9	63.0
57	4118.9	4182.6	63.7
58	4229.8	4294.2	64.4
59	4344.0	4409.1	65.1
60	4461.5	4527.3	65.8
61	4582.7	4649.2	66.5
62	4707.8	4775.0	67.2
63	4837.1	4904.9	67.8
64	4971.0	5039.4	68.4
65	5109.8	5178.8	69.0
66	5254.0	5323.6	69.6
67	5403.9	5474.0	70.1
68	5560.2	5630.8	70.6
69	5723.5	5794.6	71.1
70	5894.4	5965.9	71.5
71	6073.7	6145.6	71.9
72	6262.4	6334.7	72.3
73	6461.6	6534.3	72.7
74	6672.6	6745.7	73.1
75	6896.8	6970.3	73.5
76	7136.2	7210.0	73.1
77	7393.0	7467.1	74.1
78	7670.1	7744.5	74.4
79	7970.9	8045.6	74.7
80	8300.2	8375.2	75.0
81	8663.8	8739.0	75.2
82	9070.0	9145.4	75.4
83	9530.2	9605.8	75.6
84	10061.1	10136.9	75.8
85	10688.7	10764.6	75.9
86	11456.5	11532.5	76.0
87	12446.0	12522.1	76.1
88	13840.4	13916.4	76.0
89	16223.8	16299.5	75.7
90			37.75

MERLIN. See FALCON.

MERLON, in fortification, is that part of the parapet which is terminated by two imbrasures of a battery. Its height and thickness are the same with those of the parapet; but its breadth is generally nine feet on the inside, and six on the outside. It serves to cover those on the battery from the enemy; and is better when made of earth well beaten and close, than when built with stones; because they fly about and wound those whom they should defend.

MEROPS, in ornithology, a genus belonging to the order of picæ. The bill is crooked, flat, and carinated; the tongue is jagged at the point; and the feet are of the walking kind. The principal species are, 1. The apiaster, or bee-eater, which has an iron-coloured back; the belly and tail are of a blueish green; and the throat yellow. This bird inhabits various parts of Europe, on the continent, though not in England; yet it is said to have been seen in Sweden, and flocks of them have been met with at Anspach in Germany in the month of June. It takes the name of bee-eater from its being very fond of those insects; but, besides these, it will catch gnats, flies, cicadæ, and other insects, on the wing, like swallows. These birds make their nests in the holes in the banks of rivers, like the sand martin and kingfisher; at the end of which the female lays from five to seven white eggs, rather less than those of a blackbird. The nest itself is composed of moss. 2. The viridis, or Indian bee-eater, is green, with a black belt on the breast; and the throat and tail are black. It inhabits Bengal. 3. The erythropterus, or red-winged bee-eater, is in length six inches; the bill is one inch, and black; the upper parts of the head, body, wings, and tail-coverts, are green brown, deepest on the head and back, lightest on the rump and tail-coverts; behind the eye is a spot of the same, but of a very deep colour; the quills and tail are red, tipped with black; the last two inches in length; the throat is yellow; the under parts of the body are a dirty white; and the legs black. There are more than 20 other species.

MESEMBRYANTHEMUM, *fig-marigold*, a genus of the pentagynia order, in the icosandria class of plants, and in the natural method ranking under the 13th order, succulentæ. The calyx is quinquefid; the petals are numerous and linear; the capsule is fleshy, inferior, and monospermous. There are seventy-five species, all African plants, from the Cape of Good Hope, near 40 of which are retained in our gardens for variety. Of these only one is annual, and the most remarkable of them all: it is called the crystallinum, diamond, ficoides, or ice-plant. This singular and curious plant, being closely covered with large pellucid pimples, full of moisture, shining brilliantly like diamonds, is in great esteem. It is a very tender plant while young, and is raised annually from seed by means of hotbeds. In June it will endure the open air till October, when it perishes; but if placed in a hot-house in autumn it will often live all winter.

The other species are most durable in stem and foliage. Some are shrubby; others pendulous, with loose straggling stems, and branches inclining to the ground; while others have no stalks at all; their leaves are universally very thick, succulent, fleshy, and of many various shapes, situations, and directions; while some are punctured, or dotted with transparent points; and some have

pellucid pimples, as already mentioned. They afford a very agreeable variety at all times of the year, and merit a place in every collection. They are greenhouse plants, and are propagated by cuttings of their stalks and branches.

MESENTERY. See ANATOMY.

MESNE, he who is lord of a manor, and so has tenants holding of him, yet himself holds of a superior lord. 15 Vin. Abr.

MESNE PROCESS, is an intermediate process, which issues pending the suit, upon some collateral interlocutory matter, as to summon juries, witnesses, and the like; sometimes it is put in contradistinction to final process, or process of execution; and then it signifies all such process as intervenes between the beginning and end of a suit. 3 Black. 279.

MESPILUS, the medlar; a genus of the pentagynia order, in the icosandria class of plants; and in the natural method ranking under the 36th order, pomaceæ. The calyx is quinquefid; the petals are five; the berry is inferior and pentaspermous.

There are nine species, the principal of which are, 1. The Germanica, German mespilus, or common medlar, rises with a deformed tree-stem, branching irregularly 15 or 20 feet high; spear-shaped leaves, and brown fruit, the size of middling apples, which ripen in October, but are not eatable till beginning to decay. The varieties are, common great German medlar; smaller Nottingham medlar; spear-shaped Italian medlar. 2. The arbutifolia, arbutus-leaved mespilus, has a small, roundish, purple fruit, like haws. 3. The amelanchier, or shrubby medlar, with black fruit. 4. The chamæ-mespilus, or dwarf medlar, commonly called bastard quince, has small red fruit. 5. The cotoneaster, commonly called dwarf quince, with small roundish bright-red fruit. 6. The Cadanensis, Canada snowy mespilus, with small, purplish fruit, like haws. 7. The pyracantha, or evergreen thorn, rises with a shrubby, spinous stem, branching diffusely 12 or 14 feet high, all the shoots terminated by numerous clusters of whitish flowers; succeeded by large bunches of beautiful red berries, remaining all winter, and exhibiting a very ornamental appearance.

MESSENGERS, are certain officers chiefly employed under the direction of the secretaries of state, and always in readiness to be sent with all kinds of despatches foreign and domestic. They also, by virtue of the secretaries' warrants, take up persons for high treason, or other offences against the state. The prisoners they apprehend are usually kept at their own houses, for each of which they are allowed 6*s.* 8*d.* per day, by the government: and when they are sent abroad, they have a stated allowance for their journey.

METALS may be considered as the great instrument of all improvements: without them, many of the arts and sciences could hardly have existed. So sensible were the ancients of their great importance, that they raised those persons who first discovered the art of working them to the rank of deities. In chemistry, they have always filled a conspicuous station: at one period the whole science was confined to them; and it may be said to have owed its very existence to a rage for making and transmuting metals.

1. One of the most conspicuous properties of the metals is a particular brilliancy which they possess, and which has been called the metallic lustre. There are other bodies indeed (mica for instance) which apparently possess this peculiar lustre, but in them it is confined to the surface, and accordingly disappears when they are scratched, whereas it pervades every part of the metals. This lustre is occasioned by their reflecting much more light than any other bodies; a property which seems to depend partly on the closeness of their texture. This renders them peculiarly proper for mirrors, of which they always form the basis.

2. They are perfectly opaque, or impervious to light, even after they have been reduced to very thin plates. Silver leaf, for instance, $\frac{1}{160000}$ of an inch thick, does not permit the smallest ray of light to pass through it. Gold, however, when very thin, is not absolutely opaque: for gold leaf, $\frac{1}{280000}$ of an inch thick, when held between the eye and the light, appears of a lively green; and must therefore, as Newton first remarked, transmit the green-coloured rays. It is not improbable that all other metals, as the same philosopher supposed, would also transmit light if they could be reduced to a proper degree of thinness. It is to this opacity that a part of the excellence of the metals, as mirrors, is owing; their brilliancy alone would not qualify them for that purpose.

3. They may be melted by the application of heat, and even then still retain their opacity. This property enables us to cast them in moulds, and then to give them any shape we please. In this manner many elegant iron utensils are formed. Different metals differ exceedingly from each other in fusibility. Mercury is so very fusible, that it is always fluid at the ordinary temperature of the atmosphere; while other metals, as platinum, cannot be melted except by the most violent heat which it is possible to produce.

4. Their specific gravity is much greater than that of any other body at present known. Antimony, one of the lightest of them, is more than six times heavier than water; and the specific gravity of platinum, the heaviest of all the metals, is 23. This great density, no doubt, contributes considerably to the reflection of that great quantity of light which constitutes the metallic lustre.

5. They are the best conductors of electricity of all the bodies hitherto tried.

6. None of the metals are very hard; but some of them may be hardened by art to such a degree as to exceed the hardness of almost all other bodies. Hence the numerous cutting instruments which the moderns make of steel, and which the ancients made of a combination of copper and tin.

7. The elasticity of the metals depends upon their hardness; and it may be increased by the same process by which their hardness is increased. Thus the steel of which the balance-springs of watches are made, is almost perfectly elastic, though iron in its natural state possesses but little elasticity.

8. But one of their most important properties is malleability, by which is meant the capacity of being extended and flattened when struck with a hammer. This property, which is peculiar to metals, enables us to give the metallic bodies any form we think proper, and thus renders it easy for us to convert them into the various instruments for which we have occasion. All metals do not possess this property; but it is remarkable that al-

most all those which were known to the ancients have it. Heat increases this property considerably. Metals become harder and denser by being hammered.

9. Another property, which is also wanting in many of the metals, is ductility; by which we mean the capacity of being drawn out into wire, by being forced through holes of various diameters.

10. Ductility depends, in some measure, on another property which metals possess, namely, tenacity; by which is meant the power which a metallic wire of a given diameter has of resisting, without breaking, the action of a weight suspended from its extremity. Metals differ exceedingly from each other in their tenacity. An iron wire, for instance, $\frac{1}{10}$th of an inch in diameter, will support, without breaking, about 500lb. weight; whereas a lead wire, of the same diameter, will not support above 29lb.

11. When exposed to the action of heat and air, most of the metals lose their lustre, and are converted into earthy-like powders of different colours and properties, according to the metal and the degree of heat employed. Several of the metals even take fire when exposed to a strong heat; and after combustion the residuum is found to be the very same earthy-like substance.

12. If any of these calces, as they are called, is mixed with charcoal-powder, and exposed to a strong heat in a proper vessel, it is changed again to the metal from which it was produced. This fact is easily explained on the principles of modern chemistry; the calx is the metal combined with oxygen, or an oxide, in modern language, and by heating it with charcoal, which has a stronger attraction for oxygen, that substance is taken from the metal, and it is brought again to the metallic state. The oxygen in this process, uniting with the charcoal, forms carbonic acid gas.

The words calx and calcination, then, are evidently improper, as they convey false ideas; philosophers therefore now employ, instead of them, the words oxide and oxidizement, which were invented by the French chemists. A metallic oxide signifies a metal united with oxygen; and oxidizement implies the act of that union.

13. Metals, then, are all capable of combining with oxygen; and this combination is sometimes accompanied by combustion, and sometimes not. The new compounds formed are called metallic oxides, and in some cases metallic acids. These were formerly distinguished from each other by their colour. One of the oxides, for instance, was called black oxide, another was termed red oxide; but it is now known that the same oxide is capable of assuming different colours according to circumstances. The mode of naming them from their colour, therefore, wants precision, and is apt to mislead; especially as there occur different examples of two distinct oxides of the same metal having the same colour.

As it is absolutely necessary to be able to distinguish the different oxides of the same metal from each other with perfect precision, and as the present chemical nomenclature is defective in this respect, we may, till some better method is proposed, distinguish them from each other, by prefixing to the word oxide the first syllable of the Greek ordinal numerals. Thus the protoxide of a metal will denote the metal combined with a minimum of oxygen, or the first oxide which the metal is capable of forming; deutoxide will denote the second oxide of a metal, or the metal combined with two doses of oxygen. When a metal has combined with as much oxygen as possible, the compound formed is denoted by the term peroxide; indicating by it, that the metal is thoroughly oxidized.

Thus we have the term oxide to denote the combination of metals with oxygen in general; the terms protoxide and peroxide to denote the minimum or maximum of oxidizement; and the terms deutoxide, tritoxide, &c. to denote all the intermediate states which are capable of being formed.

14. Metals are capable also of combining with the simple combustibles. The compounds thus formed are denoted by the simple combustible which enters into the combination, with the termination uret added to it. Thus the combination of a metal with sulphur, phosphorus, or carbon, is called the sulphuret, phosphuret, or carburet of the metal. Hydrogen has not been proved capable of entering into similar combinations; neither have the simple incombustibles.

15. The metals are capable likewise of combining with each other, and of forming compounds, some of which are extremely useful in the manufacture of instruments and utensils. Thus pewter is a compound of lead and tin; brass, a compound of copper and zinc; bell-metal, a compound of copper and tin. These metallic compounds are called by chemists alloys, except when one of the combining metals is mercury. In that case the compound is called an amalgam. Thus the compound of mercury and gold is called the amalgam of gold.

16. The metals at present amount to 27; only 11 of which were known before the year 1730. They may be very conveniently arranged under three classes; namely, 1. Malleable metals; 2. Brittle and easily fusible metals; 3. Brittle and difficultly fusible metals. The metals belonging to each of these classes will be seen from the following Table:

Malleable (formerly called perfect metals).

1. Gold,	2. Platinum,	3. Silver,
4. Mercury,	5. Copper,	6. Iron,
7. Tin,	8. Lead,	9. Nickel,
10. Zinc,	11. Rhodium,	12. Palladium,
13. Iridium,	14. Osmium.	

Brittle, and easily fused.

1. Bismuth,	2. Tellurium,
3. Antimony,	4. Arsenic.

Brittle, and difficultly fused.

1. Cobalt,	2. Manganese,
3. Tungsten,	4. Molybdenum,
5. Uranium,	6. Titanium,
7. Chromium,	8. Columbium,
9, Tantolium.	

The ancients gave to the seven following metals the names of the planets, and denoted each of them by particular marks, which represented both the planets and the metals.

Gold was the	Sun, and represented by	☉
Silver .	Moon, ...	☽
Mercury .	Mercury, ...	☿
Copper .	Venus, ...	♀
Iron . .	Mars, ...	♂
Tin . .	Jupiter, ...	♃
Lead . .	Saturn, ...	♄

It seems most probable that these names were first given to the planets; and that the seven metals, the only ones then known, were supposed to have some relation to the planets or to the Gods that inhabited them, as the number of both happened to be the same. It appears from a passage in Origen, that these names first arose among the Persians. Why each particular metal was denominated by a particular planet, it is not easy to see. Many conjectures have been made, but scarcely any of them are satifactory.

As to the characters by which these metals were expressed, astrologers seem to have considered them as the attributes of the deities of the same nature. The circle, in the earliest periods among the Egyptians, was the symbol of divinity and perfection; and seems with great propriety to have been chosen by them as the character of the sun, especially as, when surrounded by small strokes projecting from its circumference, it may form some representation of the emission of rays. The semicircle is, in like manner, the image of the moon; the only one of the heavenly bodies that appears under that form to the naked eye. The character ♄ is supposed to represent the scythe of Saturn; ♃ the thunderbolt of Jupiter; ♂ the lance of Mars, together with his shield; ♀ the looking-glass of Venus; and ☿ the caduceus or wand of Mercury.

Professor Beckmann, however, who has examined this subject with much attention, thinks that these characters are mere abbreviations of the old names of the planets. "The character of Mars (he observes), according to the oldest mode of representing it, is evidently an abbreviation of the word Θουρος, under which the Greek mathematicians understood that deity; or, in other words, the first letter Θ, with the last letter ς placed above it. The character of Jupiter was originally the initial letter of Ζευς: and in the oldest manuscripts of the mathematical and astrological works of Julius Firmicus, the capital Z only is used, to which the last letter ς was afterwards added at the bottom, to render the abbreviation more distinct. The supposed looking-glass of Venus is nothing else than the initial letter distorted a little of the word Φωσφορος, which was the name of that goddess. The imaginary scythe of Saturn has been gradually formed from the two first letters of his name Κρονος, which transcribers, for the sake of despatch, made always more convenient for use, but at the same time less perceptible. To discover in the pretended caduceus of Mercury the initial letter of his Greek name Στιλβων, one needs only look at the abbreviations in the oldest manuscripts, where he will find that the Σ was once written as C; they will remark also that transcribers, to distinguish this abbreviation from the rest still more, placed the C thus ◡, and added under it the next letter τ. If those to whom this deduction appears improbable will only take the trouble to look at other Greek abbreviations, they will find many that differ still farther from the original letters they express than the present character ☿ from the C and τ united. It is possible also that later transcribers, to whom the origin of this abbreviation was not known, may have endeavoured to give it a greater resemblance to the caduceus of Mercury. In short, it cannot be denied that many other astronomical characters are real symbols, or a kind of proper hieroglyphics, that represent certain attributes or circumstances, like the characters of Aries, Leo, and others, quoted by Saumaise."

METALLURGY. When it is once ascertained that an ore of metal may be worked with advantage, the metallurgist proceeds in his operations: first extracting the ore by all the mechanical methods the art possesses; which consist in digging shafts, opening adits, employing various machines to raise the water, renew the air, bring up the ore, favour the ascent and descent of the miner, prevent the earth from giving way, &c.

In general, after having bored the ground which contains ores, or having ascertained their existence by various indications, a square perpendicular well, or shaft, is dug in the ground, sufficiently wide to place straight ladders in it; over which machinery is fixed, for the purpose of raising and lowering vessels, and in which it is sometimes necessary to fix pumps to draw off the water which is collected. If the ore is too deep for a single shaft to lead from the grass or surface, to the vein, at the bottom of the first shaft, a horizontal gallery is opened, at the end of which a second shaft is sunk, and in this manner the workmen proceed until they arrive at the bottom of the mine.

When the rock to be perforated is hard, solid, and capable of supporting itself, the shaft will not require to be guarded within; but if it is soft and friable, if it threatens to fall in during the evacuation, it becomes necessary to support the shaft and gallery with pieces of wood-work, covered with planks all round, in order to support the earth and retain the fragments, which from time to time would separate, and might maim the workmen.

One of the most important particulars of the art of exploring mines, is the renovation of the air. When it is practicable to open a gallery which shall lead from the bottom of the shaft to the day or open air, a current is easily established by this simple artifice. When this is not possible, a second shaft is sunk to the extremity of the gallery, opposite to that where the first was sunk. When one of these shafts opens at a different level from the other, the circulation and renewel of the air are easy. If the second chafts are of equal height, the current will not take place spontaneously, but must be determined by causing them to communicate with a lighted furnace.

The danger of waters which overflow the works, and retard the operations, at the same time that they threaten the safety of the workmen, is no less necessary to be provided against. If the water transudes gradually through the earth, it may be let off into the plain or the nearest river by means of a horizontal adit. If it is collected in a greater quantity, or if it is not possible to open such an adit, the water is extracted by pumps, which are moved either by a stream, or by a pond, or by vapour of water introduced, and condensed in cylinders. These last machines, called steam-engines, are at present much more common than formerly. (See STEAM ENGINE.) It is an object of great difficulty sometimes to defend the works against enormous masses of water which rush forth when, in digging, a vast subterranean reservoir is opened. These cases happily are very rare, but they are in some measure provided against by a

kind of moveable strong door, or barricado, which the workmen place at the moment when they find by the particular sound of the rock, that the waters are coming in upon them, which barricado, by separating them from the liquid, gives them time to save themselves.

The destructive elastic fluids, which so frequently are disengaged in the cavities of mines, and particularly the carbonic acid gas, and different species of mixed hydrogen gases, more or less pernicious, are also among the most formidable enemies of miners. Galleries, fires, ventilators, inflammations by means of torches held at a great distance in those parts of the mines which are mephitized by the inflammable gases, and particularly the various methods of causing fresh air to enter, are the only remedies which can be opposed to these subterraneous evils.

Few metals are found in a pure state; gold, silver, and sometimes copper, are exceptions. The other metals are generally found in the state of ores, in which they are mixed and blended with other substances, so as not to have the ductility or other qualities of metals: often, indeed, they have not the metallic lustre. Sometimes the ore is only a pure oxide, which requires no more than that the oxygen should be drawn from it by heating it with an inflammable substance. Such are all the ferruginous ochres, which are oxides of iron.

The ores of metals are generally found in the veins of mountains or rocky strata, and are always separated from the rocks on each side by a quantity of spar, quartz, or sometimes softer clay or earth. The spar is generally of the gypseous kind. These form the matrix of the ore; in English, called the rider. In different veins it is of different thicknesses; the quantity of the ore increasing as that of the matter which surrounds it diminishes. Often the ore is in branching masses wandering irregularly through it, and is often rudely mixed with the matrix in veins of different thicknesses. These are called brangled ores.

The veins or fissures of the rocky strata are sometimes only a few inches wide, and sometimes many yards. In rich mines there are immense masses of ore many feet broad. Where the veins happen not to be filled up, we find the ores crystallized round the cavity.

The ore, when separated from the matrix, generally contains some other matter; as sulphur, arsenic, or both: and sometimes an earthy substance, the whole being united into a compound which at first appears homogeneous.

The first operation on metals is to separate the ore from the matrix. When the ore is found in large masses, most of it may be dug up free from the matrix, and those pieces to which it adheres may be freed by a hammer. But as the ore is often intimately mixed with the matrix, it is necessary to try other methods.

Sometimes the whole is reduced to powder and thrown into water; the water is then put in motion, and the earthy matter floats above the ore, on account of their different specific gravity. It is still better to place the powder on a board, over which water may be made to run; being stirred while the water runs over it, the earthy parts float and are carried off, whilst the metallic parts remain behind. This operation is called washing the ore.

When the matrix is not divisible by water, a stamping-mill is employed, which consist of an axis turned by a water-wheel. On the axis there are a number of cogs, which lift up a perpendicular pillar of wood plated at bottom with iron; this falling down bruises the matrix to powder. It often happens that the matrix is harder than the ore, and in this case the ore will be reduced to a much finer powder than it. Here the ore is a much heavier substance; yet its surface may be so much increased, that it may be carried off by the water before the matrix. This may be obviated by subjecting the mass to a brisk heat, and throwing water upon it when red hot, which renders the matrix more easy to be powdered. There are many ores of this kind which undergo a fusion by heat; hence the small particles of the matrix, which are angular and irregular, contract themselves into little spheres, by which means losing part of their surface, they become specifically heavier, and fall more readily to the bottom of the water: the ore too generally loses part of the sulphur it contains, and on this account becomes specifically heavier: the stone becomes softer, and is sometimes disposed to fall into powder merely by the application of water, especially if composed of gypseous spar. Quartz is not indeed so easily heated in this way, but it becomes softer by these means; cracks and flaws are produced in it, and of consequence it is more easily divided.

After all there will in washing be some loss of the metal: hence it is found more expedient to bring the whole mass into fusion, as is practised in Germany. The fusion is performed in some of the ordinary furnaces, and commonly with the addition of particular stones, or the scoriæ of former fusions, which greatly promote the fusion of the new matter. Thus the metallic matter settles to the bottom still in the state of an ore, whence the process is called crude separation. When the ore is thus freed from its matrix, the next operations are, to separate the sulphur, arsenic, &c. which the metals may contain; and this must be done by a mild heat, because of their strong adhesion to the metals, which the metallurgists call their rapacity. If exposed to a violent heat, the arsenic will hardly separate when forced off intensely, sometimes carrying off part of the metal along with it. This treating the ore in a gentle heat is called roasting it. The workmen commonly build the ore into heaps with fuel, so that the whole may become red-hot, and the air have free passage through it. Some ores, as those of copper, require many repetitions of the process, the sulphur and arsenic adhering so closely.

In consequence of this operation, the metal remains more or less in the form of an oxide; the operation of reduction becomes therefore necessary. It is often necessary to add earths to the ores, as they often contain earths not so easily fusible, but which by mixture with others become so. The fires being kept up for some time the ore melts; and as it passes through the fuel, which is generally charcoal of wood, the oxygen, which the oxide contained, is drawn off by the charcoal forming fixed air, and the metal falls into the bason constructed for that purpose in the furnace.

Thus the metal is obtained free from earthy and stony matter, and generally from arsenic and sulphur, but it contains other metals: thus copper has always with it more or less of iron, silver a quantity of copper, &c.

Some, as lead ores when rich, are treated by immediate fusion, without previous roasting; for though it would

give a greater quantity of the metal, it would be too expensive. There are many ores in which the metal exists in the state of an oxide. Here previous roasting would be of no advantage. The ores of silver and gold require certain additions to them to attract the sulphur and arsenic, and to melt the other matter which is mixed with them, so as to dispose them to separate. See ASSAYING, &c.

METAPHOR, in rhetoric, a trope, by which we put a strange word for a proper word. See RHETORIC.

METAPHYSICS. It is remarkable that scarcely any two writers are agreed with respect to the meaning of the word metaphysics. One lexicographer tells us, somewhat obscurely, that it is "the doctrine of the general affections of substances existing." Another that "it is a science which treats of being as such in the abstract." While a third most gravely assures us, it means "that part of philosophy which considers the nature and properties of thinking beings." This last definition must evidently be unfounded, since "the nature and properties of thinking beings" are either a branch of natural philosophy or of logic. See LOGIC.

The word seems to have originated with Aristotle, who has termed a treatise which is placed after his Physics, μετα τα φυσικα. So that it may mean either something "beyond Physics," or merely "an appendix to his physics" or natural history. This treatise chiefly relates to the intellectual world.

The mode in which authors have treated of metaphysics is as various as their definitions of the term. One author, under the form of a treatise of metaphysics, presents us with a discussion on abstract words, their meaning and application; another with an inquiry into the faculties and operations of the human mind; a third with a volume of theology, a dissertation on the being and attributes of God, and the nature of spiritual and celestial intelligences; and a fourth with a treatise of ethics or moral philosophy.

A science so subtle, so indefinite, so evasive, which, under so many Proteus forms, eludes our grasp, is scarcely a proper subject for a practical work like this. What are metaphysics? Every thing! Nothing! Yet there are some subjects which the learned have agreed in calling metaphysical: such were the discussions between Clarke and Leibnitz concerning the free agency of man; such were the disputes concerning identity and diversity which formerly agitated the schools, and those upon the origin of evil; and if we were called upon to point out a most able and rational work, into which metaphysics are introduced with propriety and ability, we should name Cudworth's Intellectual System.

METATARSUS. See ANATOMY.

METEOR. This term is by some writers made to comprehend all the visible phenomena of meteorology, but it is more generally confined to luminous bodies appearing suddenly at uncertain times, and with more or less of motion in the atmosphere. These may be reduced under three classes, viz. fireballs, falling or shooting stars, and ignes fatui.

Those phenomena which are classed together under the general appellation of fire-balls, were divided by the ancients into several species, according to the external form or appearance which they assumed. They were also regarded by them in a much more formidable light than by us; as being the certain prognostics of great and awful events in the moral and political world. Even the philosophic Cicero himself speaks of the "ab occidente faces," as the certain harbingers or indications of those bloody scenes which in his time convulsed and desolated the Roman commonwealth.

Under the general name of comets, Pliny enumerates a variety of these phenomena. If the fire commences at one extremity of the meteor, and burns by degrees, he terms it, from its form and appearance, a lamp or torch; if an extended mass of fire passes longitudinally through the atmosphere, he calls it a dart; and if its length and magnitude are considerable, and it maintains its station for any space of time, it is a beam; and if the clouds seem to part, and emit a quantity of fire, he terms it a chasm; but this last appears to be, strictly speaking, an electrical phenomenon, indeed only a strong and vivid flash of lightning.

Several instances of these meteors are recorded by the same author. During the spectacle of gladiators exhibited by Germanicus, one of them passed rapidly by the faces of the spectators at noon-day. A meteor of that species which he calls a beam, he adds, was seen when the Lacedemonians were defeated at sea, in that memorable engagement which lost them the empire at sea. He also mentions a sanguineous kind of meteor, a flame as red as blood, which fell from heaven about the 107th Olympiad, when Philip of Macedon was concerting his wicked plan for enslaving the republics of Greece. He relates, that when he was himself on the watch during the night in the Roman camp, he was a spectator of a similar appearance—a number of resplendent lights fixed upon the palisadoes of the camp, similar, he says, to those which mariners speak of as attaching themselves to the masts and yards of a ship.

In tropical climates these meteors are more common and more stupendous than in these more temperate regions. "As I was riding in Jamaica," says Mr. Barbham, "one morning from my habitation, situated about three miles north-west from St. Jago de la Vega, I saw a ball of fire, appearing to me about the bigness of a bomb, swiftly falling down with a great blaze. At first I thought it fell into the town; but when I came nearer, I saw many people gathered together, a little to the southward, in the savannah, to whom I rode up, to inquire the cause of their meeting: they were admiring, as I found, the ground's being strangely broken up and ploughed by a ball of fire, which, as they said, fell down there. I observed there were many holes in the ground; one in the middle of the bigness of a man's head, and five or six smaller round about it, of the bigness of one's fist, and so deep as not to be fathomed by such implements as were at hand. It was observed also, that all the green herbage was burnt up near the holes; and there continued a strong smell of sulphur near the place for some time after."

Ulloa gives an account of one of a similar kind at Quito. "About nine at night," says he, "a globe of fire appeared to rise from the side of the mountain Pichinca, and so large, that it spread a light over all the part of the city facing that mountain. The house where I lodged looking that way, I was surprised with an extraordi-

nary light darting through the crevices of the window-shutters. On this appearance, and the bustle of the people in the street, I hastened to the window, and came time enough to see it, in the middle of its career, which continued from west to south, till I lost sight of it, being intercepted by a mountain that lay between me and it. It was round, and its apparent diameter about a foot. I observed it to rise from the sides of Pichinca, although, to judge from its course, it was behind that mountain where this congeries of inflammable matter was kindled. In the first half of its visible course it emitted a prodigious effulgence, then it began gradually to grow dim; so that, upon its disappearing behind the intervening mountain, its light was very faint."

Meteors of this kind are very frequently seen between the tropics; but they sometimes also visit the more temperate regions of Europe. We have the description of a very extraordinary one, given us by Montanari, that serves to show to what great heights, in our atmosphere, these vapours are found to ascend. In the year 1676, a great globe of fire was seen at Bononia, in Italy, about three quarters of an hour after sunset. It passed westward with a most rapid course, and at the rate of not less than 160 miles in a minute, which is much swifter than the force of a cannon ball, and at last stood over the Adriatic sea. In its course it crossed over all Italy; and, by computation, it could not have been less than 38 miles above the surface of the earth. In the whole line of its course, wherever it approached, the inhabitants below could distinctly hear it, with a hissing noise, resembling that of a firework. Having passed away to sea, towards Corsica, it was heard at last to go off with a most violent explosion, much louder than that of a cannon; and immediately after, another noise was heard like the rattling of a great cart upon a stony pavement, which was probably nothing more than the echo of the former sound. Its magnitude, when at Bononia, appeared twice as long as the moon one way, and as broad the other; so that, considering its height, it could not have been less than a mile long, and half a mile broad. From the height at which this was seen, and there being no volcano in that quarter of the world whence it came, it is more than probable that this terrible globe was kindled on some part of the contrary side of the globe; and thus, rising above the air, and passing in a course opposite to that of the earth's motion, in this manner it acquired its amazing rapidity.

Two of these meteors appeared in this country in the year 1783, of which a most particular and truly philosophical account and ingenious solution, by Dr. Blagden, are published in the Philosophical Transactions of the following year; and as his account will apply to many phenomena of the kind, we cannot take any better method to elucidate this part of the subject, than by presenting our readers with a short abstract of this very curious and learned memoir.

The first of the two meteors in question was seen on the 18th of August, and was, in appearance, a luminous ball, which rose in the N. N. W. nearly round: it, however, soon became elliptical, and gradually assumed a tail as it ascended, and, in a certain part of its course, seemed to undergo a remarkable change, compared to bursting; after which it proceeded no longer as an entire mass, but was apparently divided into a cluster of balls of different magnitudes, and all carrying or leaving a train behind, till, having passed the east, and verging considerably to the south, it gradually descended, and was lost out of sight. The time of its appearance was about sixteen minutes past nine in the evening, and it was visible about half a minute. It was seen in all parts of Great Britain, at Paris, at Nuits in Burgundy, and even at Rome; and is supposed to have described a tract of 1000 miles at least over the surface of the earth. It appears to have burst and reunited several times; and the first bursting of it which was noticed seems to have been sowewhere over Lincolnshire, perhaps near the commencement of the fens. This change in the meteor corresponds with the period in which it suffered a deviation from its course. If, indeed, the explosion was any kind of effort, we cannot wonder that the body should be diverted by it from its direct line; and, on the other hand, it seems equally probable, that if it was forced by any cause to change its direction, the consequence would naturally be a separation of its parts.

The illumination of these meteors is often so great as totally to obliterate the stars, to make the moon look dull, and even to affect the spectators like the sun itself. When this meteor was observed at Brussels, the moon appeared quite red, but when it was passed, recovered its natural light. This effect, the doctor remarks, must have depended on the contrast of colour, and shows how large a proportion of the blue rays enters into that light which could even make the *silver* moon appear to have an excess of red. The body of the fire-ball, even before it burst, did not appear of an uniform brightness, but consisted of lucid and dull parts, which were constantly changing their respective positions, so that the whole effect was to some eyes like an internal agitation or boiling of the matter. By the best accounts that could be procured concerning the height of the meteor, it seems to have varied from 35 to 60 miles. In these two last particulars it seems to have wonderfully corresponded with some other phenomena of the same kind.

A report was heard some time after the meteor disappeared, and this report was loudest in Lincolnshire and the adjacent parts, and again in the eastern part of Kent: the report we may therefore suppose to be the effect of the two explosions of the body, first over Lincolnshire, and afterwards when it entered the continent: a hissing sound was said also to have accompanied the progress of the meteor. Judging from the height of the meteor, its bulk is conjectured to have been not less than half a mile in diameter: and when we consider this bulk, its velocity cannot fail to astonish us, which is supposed to be at the rate of more than 40 miles in a second.

The other meteor, which appeared on the 4th of October, 1783, at 48 minutes past six in the evening, was much smaller than the former, and of a much shorter duration. It was first perceived to the northward, as a stream of fire, like the common shooting stars, but large; but presently burst out into that intensely bright blueish flame, which is peculiar to such meteors. It left behind it a dusky-red streak of fire, and, except this, had no tail, but was nearly globular. After moving not less than 10 degrees in this bright state, it became suddenly extinct without any explosion. The height of the me-

teor must have been between 40 and 50 miles; and its duration was not more than three seconds.

The doctor is of opinion, that the general cause of these phenomena is electricity, which opinion he grounds upon the following circumstances: 1st, The velocity of these meteors, in which they correspond with no other body in nature but the electrical fluid. 2dly, The electrical phenomena attending meteors, the lambent flames, and the sparks proceeding from them, which have sometimes damaged ships and houses in the manner of lightning; and, added to these, the hissing sound, resembling that of electricity passing from a conductor. As a third argument in favour of this hypothesis, the doctor remarks the connection of meteors with the northern lights. Instances are recorded, where northern lights have been seen to join, and form luminous balls, darting about with great velocity, and even leaving a train like fireballs. The aurora borealis appears to occupy as high, if not a higher, region above the surface of the earth, as may be concluded from the very distant countries to which it has been visible at the same time. 4thly, The most remarkable analogy, the doctor thinks, is the course of at least all the larger meteors, which seems to be constantly from or towards the north or north-west quarter of the heavens. Of above forty different fireballs described in the Philosophical Transactions, twenty are so described, that it is certain their course was in that direction: only three or four seem to have moved the contrary way; and with respect to the remainder, it is left doubtful, from the imperfect state of the relations.

Notwithstanding the doctor's ingenious arguments, we connot subscribe to the opinion, that these phenomena are altogether electrical. The duration of the fire-ball, the unequal consistency of the mass, and several other points in the narration, seem to indicate that its materials were of a less rare and evanescent nature than the electric fire.

The following probably was electrical.

On board the Montague, under the command of admiral Chambers, in lat. 42° 48′, long. 9° 3′, on the 4th of November, 1749, about ten minutes before twelve, as the author, Mr. Chambers, was taking an observation, one of the quarter-masters desired he would look to the windward. On directing his eye that way, he observed a large ball of blue fire about three miles distance from them. They immediately lowered the topsails, but it came so fast upon them, that before they could raise the main-tack, they observed the ball rise almost perpendicularly, and not above 40 or 50 yards from the main-chains, when it went off with an explosion as great as if hundreds of cannon had been discharged at the same time, leaving behind it a strong sulphureous smell. By this explosion, the main topmast was shattered in pieces, and the main-mast rent quite down to the keel. Five men were knocked down, and one of them was greatly bruised, and some other damages of less importance was done to the ship. Just before the explosion, the ball seemed to be of the size of a large mill-stone.

The shooting or falling star is a common phenomenon; but though so frequently observed, the great distance and transcient nature of these meteors have hitherto frustrated every attempt to ascertain their cause. The connection of these with an active state of the atmospheric electricity, is however certain from observation; and we have more reason to consider them as electric scintillæ than as solid or fluid matter in the act of combustion. They precede a change of wind.

Concerning the nature and composition of the *ignis fatuus*, or Will-with-a-wisp, there is less dispute; the generality of philosophers being agreed, that it is caused by some volatile vapour of the phosphoric kind, probably the phosphorized hydrogen gas. The light from putrescent substances, particularly putrid fish, and those sparks emitted from the sea, or sea-water when agitated, in the dark, correspond in appearance with this meteor. Sir Isaac Newton defines the ignis fatuus to be, "a vapour shining without heat;" and it is usually visible in damp places, about dunghills, burying-grounds, and other situations which are likely to abound with phosphoric matter.

A remarkable ignis fatuus was observed by Mr. Derham, in some boggy ground, between two rocky hills. He was so fortunate as to be able to approach it within two or three yards. It moved with a brisk and desultory motion about a dead thistle, till a slight agitation of the air, occasioned, as he supposed, by his near approach to it, caused it to jump to another place; and as he approached, it kept flying before him. He was near enough to satisfy himself that it could not be the shining of glow-worms or other insects: it was one uniform body of light.

M. Beccaria mentions two of these luminous appearances, which were frequently observed in the neighbourhood of Bologna, and which emitted a light equal to that of an ordinary faggot. Their motions were unequal, sometimes rising, and sometimes sinking towards the earth; sometimes totally disappearing, though in general they continued hovering about six feet from the ground. They differed in size and figure; and, indeed, the form of each was fluctuating, sometimes floating like waves, and dropping sparks of fire. He was assured there was not a dark night in the whole year in which they did not appear; nor was their appearance at all affected by the weather, whether cold or hot, snow or rain. They have been known to change their colour from red to yellow; and generally grew fainter as any person approached, vanishing entirely when the observer came very near to them, and appearing again at some distance.

Dr. Shaw also describes a singular ignis fatuus, which he saw in the Holy Land. It was sometimes globular, or in the form of the flame of a candle; and immediately afterwards spread itself so much, as to involve the whole company in a pale inoffensive light, and then was observed to contract itself again, and suddenly disappear. In less than a minute, however, it would become visible as before, and run along from one place to another; or would expand itself over more than three acres of the adjacent mountains. The atmosphere at this time, he adds, was thick and hazy.

In a superstitious age we cannot wonder that these phenomena have all been attributed to supernatural agency: it is one of the noblest purposes of philosophy to release the mind from the bondage of imaginary terrors; and by explaining the modes in which the Divine Providence disposes the different powers of nature, to elevate our thoughts to the One First Cause; to teach us to see "God in all, and all in God."

METEORIC STONES. Almost all the larger fire-

balls have been observed to disappear with a loud explosion; and it was almost constantly affirmed that heavy stony bodies fell from them. But though several well authenticated accounts of the fall of such stones had been from time to time published, little credit was given to them: nor did they indeed attract the attention of philosophers, till Dr. Chladni published a dissertation on the subject in 1794. Two years after, Mr. King published a still more complete collection of examples, both ancient and modern; many of them supported by such evidence that it was impossible to reject it. These two dissertations excited considerable attention: but the opinion that stones had really fallen from the atmosphere was considered as so extraordinary, and so contrary to what we know of the constitution of the air, that most people hesitated, or refused their assent. Meanwhile Mr. Howard took a different method of investigating the subject. He not only collected all the recent and well-authenticated accounts of the fall of stony bodies, and examined the evidence of their truth, but procured specimens of the stones which were said to have fallen in different places, compared them together, and subjected them to a chemical analysis. The result was, that all these stony bodies differ completely from every other known stone; that they all resemble each other; and that they are all composed of the same ingredients. His dissertation on the subject was published in the Philosophical Transactions for 1802. The proofs which this admirable dissertation contains, that the stony bodies in question really fell from the atmosphere, are quite irresistible. Indeed, their external characters and chemical analysis would alone decide the point: for it is quite inconceivable that in India, England, France, Germany, and Italy, in climates and soils exceedingly different from each other, stones should have been pointed out which differed from every other mineral in the countries where they were found, and which exactly resembled one another, provided these had not had the same origin. The chemical analysis of Howard was soon after repeated, and verified, by Vauquelin and Klaproth.

Most of the stones which have fallen from the atmosphere have been preceded by the appearance of luminous bodies or meteors. These meteors burst with an explosion, and then the shower of stones falls to the earth. Sometimes the stones continue luminous till they sink into the earth; but most commonly their luminousness disappears at the time of the explosion. These meteors move in a direction nearly horizontal, and they seem to approach the earth before they explode. The following table, drawn up by Mr. Izarn, exhibits the collection of the best authenticated instances of the falling of stones, &c. from the atmosphere hitherto observed, together with the time when they fell, and the persons on whose evidence the fact rests.

Substances.	*Places where they fell.*	*Period of their fall.*	*Testimony.*
Shower of stones	At Rome	Under Tullus Hostilius	Livy
Shower of stones	At Rome	Consuls C. Martius & M. Torquatus	J. Obsequens
Shower of iron	In Lucania	Year before the defeat of Crassus	Pliny
Shower of mercury	In Italy		Dion
A very large stone	Near the river Negos, Thrace	Second year of the 78th Olympiad	Pliny
Three large stones	In Thrace	Year before J. C. 452	Ch. of Count Marcellin
Shower of fire	At Quesnoy	January 4th, 1717	Geoffroy le Cadet
Stone of 72lbs.	Near Larissa, Macedonia	January 1706	Paul Lucas
About 1200 stones—one of 120lbs. Another of 60lbs.	Near Padua in Italy	In 1510	Carden, Varcit
Another of 59lbs.	On Mount Vaiser, Provence	November 27th, 1627	Gassendi
Shower of sand for 15 hours	In the Atlantic	April 6th, 1719	Pere la Feuillée
Shower of sulphur	Sodom and Gomorrah		Moses
Sulphureous rain	In the duchy of Mansfield	In 1658	Spangenberg
The same	Copenhagen	In 1645	Olaus Wormius
Shower of sulphur	Brunswick	October 1721	Siegesber
Ditto of a viscid unknown matter	Ireland	In 1695	Muschenbroeck
Two large stones weighing 20lbs.	Liponas in Bresse	September 1753	Delalande
A stony mass	Niort, Normandy	In 1750	Delalande
A stone of 7½lbs.	At Luce in Le Maine	September 13th, 1768	Bachelay
A stone	At Air in Artois	In 1768	Gurson de Boyaval
A stone	In Le Cotentin	In 1768	Morand
Extensive shower of stones	Environs of Agen	July 24th, 1790	St. Amand, Baudin, &c.
About 12 stones	Sienna, Tuscany	July 1794	Earl of Bristol
A large stone of 56lbs.	Wood-Cottage, Yorkshire	December 13th, 1795	Captain Topham
A stone of about 20lbs.	Salé, department of the Rhone	March 17th, 1798	Lelievre and De Drée
A stone of 10lbs.	In Portugal	February 19th, 1796	Southey
Shower of stones	Benares, East Indies	December 19th, 1798	J. Lloyd Williams, Esq.
Shower of stones	At Plann, near Tabor, Bohemia	July 3d, 1753	B. de Born
Mass of iron, 70 cubic feet	America	April 5th, 1800	Philosophical Magazine
Mass of ditto, 14 quintals	Abakank, Siberia	Very old	Pallas, Chladni, &c.
Shower of stones	Barboutan, near Roquefort	July 1789	Darcet, jun. Lomet, &c.
Large stone, 260lbs.	Ensisheim, Upper Rhine	November 7th, 1492	Butenschoen
Two stones, 200 and 300lbs.	Near Verona	In 1762	Acad. de Bourd
A stone of 20lbs.	Sales, near Ville-Franche	March 12th, 1798	De Drée
Several ditto, from 10 to 17lbs.	Near L'Aigle, Normandy	April 26th, 1803	Fourcroy

The stony bodies when found are always hot. They commonly bury themselves some depth under ground. Their size differs from a few ounces to several tons. They are usually roundish, and always covered with a black crust. In many cases they smell strongly of sulphur. The black crust, from the analysis of Howard, consists chiefly of oxide of iron.

The outer surface of these stones is rough. When broken, they appear of an ash-grey colour, and of a granular texture like a coarse sandstone. When examined with a microscope, four different substances may be discovered, of which the stone is composed: 1st, A number of spherical bodies, varying in size from a pin's head to a pea; of a greyish-brown colour, opaque, breaking easily in every direction, of a compact texture, capable of scratching glass, and of giving a few feeble sparks with steel. 2d, Fragments of pyrites of an indeterminate shape, of a reddish-yellow colour, granular, and easily reduced to powder. The powder has a black colour. 3d, Grains of iron in the metallic state, scattered like the pyrites through the stone. 4th, The three substances just mentioned are cemented together by a fourth of an earthy consistence, and so soft that all the other substances may be easily separated by the point of a knife or the nail, and the stone itself crumbled to pieces between the fingers. This cement is of a grey colour. The proportion and size of these different constituents vary considerably in different specimens; but all of them bear a striking resemblance to each other. Their specific gravity varies from 3.352 to 4.281.

From the analysis of Howard, which was conducted with much precision and address, and which has been fully confirmed by Vauquelin and Klaproth, we learn, that the black crust consists of a compound of iron and nickel, partly metallic and partly oxydized. The pyrites consists of iron, nickel, and sulphur. The metallic grains consist of iron, combined with about one-third of its weight of nickel, and the yellow globules are composed of silica, magnesia, iron, and nickel. The count Bournon observes, that these globules resemble the chrysolite of Werner, and that their chemical analysis corresponds exactly with Klaproth's analysis of that mineral. The earthy cement consists of the very same substances, and nearly in the same proportions, as the globular substances. But it will be necessary to exhibit a specimen of some of the analyses, as published by the philosophers to whom we are indebted for them. A stone which fell at Benares in India, was analysed by Howard. The pyrites consisted of,

2.0	Sulphur
10.5	iron
1.0	nickel
2.0	earths and foreign bodies.
15.5	

The spherical bodies,

50.0	silica
15.0	magnesia
34.0	oxide of iron
2.5	oxide of nickel.
101.5	

The earthy cement,

48.0	silica
18.0	magnesia
34.0	oxide of iron
2.5	oxide of nickel.
102.5	

A stone which fell in Yorkshire, deprived as much as possible of its metallic particles, gave Mr. Howard from 150 grains,

75	silica
37	magnesia
48	oxide of iron
2	oxide of nickel
162.	

The increase of weight was owing to the oxydizement of the metallic bodies.

Stones which fell at Laigle in France in 1803, yielded by the analysis of Vauquelin and Fourcroy,

54	silica
36	oxide of iron
9	magnesia
3	oxide of nickel
2	sulphur
1	lime
105.	

The celebrated stone which fell at Ensisheim, in Alsace, in 1492, yielded to the same philosophers,

56.0	silica
30.0	oxide of iron
12.0	magnesia
2.4	nickel
3.5	sulphur
1.4	lime.
105.3	

5. The experiments of Howard, thus confirmed by others, and supported by the most respectable historical evidence, having demonstrated that these stony bodies really do fall from the heavens, it was natural to expect that various attempts would be made to account for their appearance. But such is the obscurity of the subject, so little progress have we made in the science of meteorology, that no opinion in the slightest degree probable has hitherto been advanced. It was first supposed that the bodies in question had been thrown out of volcanoes; but the immense distance from all volcanoes at which they have been found, and the absence of all similar stones from volcanic productions, render this opinion untenable. Chladni endeavoured to prove, that the meteors from which they fell were bodies floating in space, unconnected with any planetary system, attracted by the earth in their progress, and kindled by their rapid motion through the atmosphere. But this opinion is not susceptible of any direct evidence, and can scarcely be believed, one would think, even by Dr. Chladni himself. Laplace suggests the probability of their having been thrown off by the volcanoes of the moon: but the meteors which almost always accompany them, and the swiftness of their horizontal motion, militate too strongly against this opinion. The greater number of philosophers con-

sider them, with Mr. King and sir William Hamilton, as concretions actually formed in the atmosphere. This opinion is undoubtedly the most probable of all; but in the present state of our knowledge, it would be absurd to attempt any explanation of the manner in which they are formed. The masses of native iron found in South America, in Siberia, and near Agnam, contain nickel, as has been ascertained by Proust, Howard, and Klaproth, and resemble exactly the iron found in the stones fallen from the atmosphere. We have every reason, therefore, to ascribe to them the same original; and this accordingly is almost the uniform opinion of philosophers. Klaproth has shown, that real native iron is distinguished from meteoric iron by the absence of nickel.

Upon the whole, we may consider these stony and metallic masses as fragments of fire-balls which have burst in the atmosphere; but the origin and cause of these fire-balls will perhaps for ages baffle all the attempts of philosophers to explain them.

METEOROLOGY, the doctrine of meteors, or the study of the variable phenomena of the atmosphere, in which also is commonly included the art of deducing probable conjectures on the future state of the weather.

The latter branch of this science was successfully cultivated by the ancients; and it subsists at this day among those whom necessity, arising from the nature of their occupations, renders diligent in comparing the present appearances of the atmosphere, and circumstances depending on its present state, with the changes which succeed. The aphorisms of Virgil, in his Georgics, are beautiful examples of this kind of skill, and possess philosophical, in an equal degree with poetical, merit.

The atmosphere may be considered in respect of the direction of its currents or winds; of the variations in its gravity or pressure; of the changes in its temperature; of the state of the electricity which it exhibits; and lastly, as to the visible phenomena which are supposed to depend on the foregoing; and the regular notation of which, together with the other indications, will be found the only successful way of prosecuting this study. Since the invention of philosophical instruments, an attention to these has too much superseded the ancient, and, singly considered, the more rational, way of deducing prognostics: it has been accordingly left to the ploughman, the mariner, and the fisherman; whose experience being successful without, would undoubtedly be more so with, the aid of instruments.

Winds, though proverbially uncertain in some climates, are yet not without a striking degree of regularity and system, if we consider the whole atmosphere; and there is a part of the world where the wind is so constantly in one quarter, that *windward*, in common speech, stands for eastern, and *leeward* for western. We want only a more extensive set of observations to render exceedingly probable the following hypothesis: That a large portion of the whole atmosphere moves constantly from east to west round the earth, on and near the equator; that this is supplied and impelled by air from the temperate and cold latitudes on each side toward the poles; which again receive, by a superior current, the overflow of the tropical regions, where the air, rarefied by the heat, is constantly rising and tending to lateral diffusion. This opinion, as will appear hereafter, is supported by many facts; and it is certainly in theory a most beautiful provision for that constant internal movement in the mass of the air, without which it could not probably serve the salutary purposes to animal and vegetable life which it does at present. The exceptions both in regular and irregular winds to such an hypothesis may perhaps be accounted for when the superior currents, which interest philosophers alone, and of which we know very little, shall have been more investigated. See Wind.

Variable winds evidently stamp the nature of every climate, and therefore depend upon causes which act with uniformity, notwithstanding all their apparent irregularity. They are all intimately connected with each other, and probably succeed each other in a certain order, though that order has not hitherto been observed. All that can be done at present is, to offer a few unconnected remarks.

Winds appear usually to begin at that point towards which they blow. They must therefore be owing to a rarefaction or displacing of the air in some particular quarter, either by the action of heat or some other cause. This is more particularly the case when the wind blows with violence. Hurricanes are uniformly preceded by a great fall of the barometer; and the wind often flows in every direction towards the place where the barometer stands so low. One would be tempted in this case to suppose the sudden decomposition of a portion of the atmosphere. Strong north-east winds have been repeatedly observed beginning at the quarter towards which they flow. In 1740, Dr. Franklin was prevented from observing an eclipse of the moon at Philadelphia by a north-east storm, which came on about seven o'clock in the evening. He was surprised to find afterwards that it had not come on at Boston till near 11 o'clock: and upon comparing all the accounts which he received from the several colonies of the beginning of this and other storms of the same kind, he found it to be always an hour later the farther north-east for every 100 miles.

"From thence (says he) I formed an idea of the course of the storm, which I will explain by a familiar instance. I suppose a long canal of water stopped by a gate. The water is at rest till the gate is opened; then it begins to move out through the gate, and the water next the gate is first in motion, and moves on towards the gate; and so on successively, till the water at the head of the canal is in motion, which it is last of all. In this case all the water moves indeed towards the gate; but the successive times of beginning the motion are in the contrary way, viz. from the gate back to the head of the canal. Thus, to produce a north-east storm, I suppose some great rarefaction of the air in or near the Gulf of Mexico; the air rising thence has its place supplied by the next more northern, cooler, and therefore denser and heavier air; a successive current is formed, to which our coast and inland mountains give a north-eastern direction."

A similar storm was observed by Dr. Mitchell in 1802. It began at Charleston on the 21st February, at two o'clock in the afternoon; at Washington, which lies several hundred miles to the north-east, it was not observed till five o'clock; at New York it began at ten in the evening; and at Albany not till day-break of the 22d. Its motion, from this statement, was 1100 miles in 11 hours, or 100 miles in the hour.

A remarkable storm of the same kind, and accompanied by an easterly wind, was observed in Scotland on the 8th of February 1799. It was attended by a very heavy fall of snow, and the motion of the wind was much slower. At Falkirk it began to snow at six in the evening of the 7th; at Edinburgh, about one o'clock in the morning of the 8th; and at Dunbar, at eight o'clock in the morning. It lasted 11 hours, and did not travel above 100 miles during that time.

The north-east wind blows most frequently with us during the spring months; and from the observations made by captain Cook, it appears, that the same wind prevails during the same period in the northern Pacific. Hence it appears, that at that season the cold air from the north of Europe and America flows into the Atlantic and Pacific. Hence the reason of its uncommon coldness, dryness, and density.

It is very common to observe one current of air blowing at the surface of the earth, while a current flows in a contrary direction in the higher strata of the atmosphere. Three such winds have been observed blowing in contrary directions all at the same time. It is affirmed that changes of weather generally begin in the upper strata of the air, the wind which blows there gradually extending itself to the surface of the earth.

With regard to the pressure of the atmosphere, it is every where variable, as appears by the barometer; which indicates to us the weight of a column of air, extending to the top of the atmosphere, and whose base is equal to that of the mercury. At the level of the sea, where the column of air is longest, the mean height of the barometer is thirty inches. This sir George Shuckburgh found to be the case in the Mediterranean and the Channel, in the temperature of 55° and 60°; Mr. Bouguer, on the coast of Peru, in the temperature of 84°; and lord Mulgrave, in latitude 80°. The mean height of the barometer is less, the higher any place is situated above the level of the sea, because the column of air which supports the mercury is the shorter.

Between the tropics the variations of the barometer are exceedingly small; and it is remarkable, that in that part of the world it does not descend above half as much for every 200 feet of elevation as it does beyond the tropics.

As the latitude advances towards the poles, the range of the barometer gradually increases, till at last it amounts to two or three inches. This gradual increase will appear from the following table:

TABLE
Of the Range of the Barometer.

Latitude.	Places.	Range of the Barometer. Greatest.	Annual.
0° 0′	Peru	0.20	—
22 23	Calcutta	0.77	—
33 55	Cape Town	—	0.89
40 55	Naples	1.00	—
51 8	Dover	2.47	1.80
53 26	Liverpool	2.89	1.96
59 56	Petersburgh	3.45	2.77

In North America, however, the range of the barometer is a great deal less than in the corresponding European latitudes. In Virginia, for instance, it never exceeds 1.1.

The range of the barometer is greater at the level of the sea than on the mountains; and in the same degree of latitude, the extent of the range is in the inverse ratio of the height of the place above the level of the sea.

From a table published by Mr. Cotte, in the Journal de Physique, it seems exceedingly probable that the barometer has always a tendency to rise from the morning to the evening; and that this tendency is greatest between two o'clock in the afternoon and nine at night, at which hour the greatest elevation takes place; that the elevation of nine o'clock differs from that of two by $\frac{4}{12}$ths, while that at two differs from the morning elevation only by $\frac{1}{12}$; and that in certain climates the greatest elevation takes place at two o'clock. The following is a part of the table on which these observations are founded, reduced to the English standard.

Places.	Years of observation.	Mean Height of the Barometer. Morning.	Noon.	Evening.	Year.
Arles . . .	6	29.9347	29.9347	29.9413	29.9347
Arras . . .	6	29.6683	29.6683	29.6832	29.6758
Bourdeaux . .	11	29.7212	29.8385	29.8385	29.8385
Cambray . .	13	29.8756	29.8682	29.8756	29.8756
Chinon . .	12	29.7719	29.7795	29.8001	29.7869
Dunkirk . .	8	29.9199	29.9347	29.9347	29.9273
Hagenau . .	10	29.5648	29.5648	29.5741	29.5648
Laon . . .	7	29.3354	29.3206	29.3429	29.3354
Lisle . . .	6	29.9165	29.9274	29.2347	29.9077
Mayenne . .	7	29.7172	29.7056	29.7127	29.7127
Manheim . .	5	29.6167	29.6018	29.6167	29.6093
Montmorenci .	22	29.6536	29.6536	29.6610	29.6536
Mulhausen . .	7	29.1873	29.1800	29.1873	29.1873
Obernheim . .	12	29.4834	29.4665	29.4764	29.4764
Paris . . .	67	29.8902	29.8607	29.8756	29.8756
Poitiers . .	12	29.7276	29.7276	29.7276	29.7276
Rouen . . .	11	29.8607	29.8535	29.8535	29.8535
Rome . . .	3	29.8607	29.8460	29.8756	29.8607
St. Maurice le Gerard	10	29.8016	29.8016	29.8090	29.8016
Troyes . .	10	29.6885	29.6979	29.6885	29.6885

The range of the barometer is greater in winter than in summer. Thus at York the mean range of the barometer, during October, November, December, January, February, March, of the year 1774, was 1.42, and for the six summer months, 1.016.

It is probable that the variations of the barometer, as well as those of the thermometer, are susceptible of what we may term a local character for each tract or country differing in climate. This will be most readily discovered by the following mode of investigation: Prepare a sheet of paper ruled in squares with pale ink; the hori-

zontal lines agreeing with the inches and decimal divisions of the scale of the barometer; the perpendicular, which may be about twice as distant, representing divisions of time. It will be convenient to consider each line as denoting midnight, and to mark the days of the month at the top of the columns thus defined. On this scale let the several notations of any register of the barometer be set down by means of a dot for each, placed in the part of the scale where it may point out the time and the elevation. The desired number of notations thus made, a curve may be drawn through the series of dots, which will represent at one view the course of the barometer for the time. It will be found, on comparing a number of these curves, that they characterize, in a certain degree, not only the latitude and season, but the locality of the observations. So that although the most obvious resemblances may be traced in different years of the same register, yet the general appearance of registers from different climates, will be found to differ in all respects. In this way may be seen at one view both the correspondence between the latitude of elevation above the sea of any place, and the range at that place; and the coincidence between the movements of the barometer, and the other phenomena of the weather. It is obvious that the same mode, and even the same scale, may be made to serve for temperature also, by marking degrees upon the horizontal lines, and changing the appearance of the line representing temperature, so as to make it readily distinguishable from the other curve. There is a correspondence in this climate between the two instruments, which will thus often become conspicuous. It consists in an elevation of temperature after a rise of the barometer, and vice versa: the exceptions of this occur chiefly at the setting in of frost, and when it rains with the wind from the eastward. But the most remarkable circumstance which has been thus brought to light is, an influence which the sun and moon exercise over the atmosphere in respect to its pressure; and which is detailed in a series of observations, accompanied with a chart of this kind, for the year 1798, in the Philosophical Magazine, vol. vii. p. 355.

The effect of this is, a tendency in the atmosphere to gain weight while the moon is passing to either quarter, and vice versa to lose it during the approach of full or new moon. The actual change which on a mean of ten years is found always to take place at London, amounts only to two-tenths of an inch in the barometer, which thus occurs twice in each moon. The apparent influence is often much greater for a considerable time together. The specimen of the register alluded to, which is given Plate LXXXIV. Meteorology, will elucidate the whole of the foregoing observations.

There is something in these movements of the atmosphere very much resembling the waves producible in dense fluids. Thus a sudden and great depression in the barometer is followed by an equally sudden rise, which is often carried beyond the point from which the original movement commenced. After a continued gradual rise on the other hand, there usually occurs a similar depression. Except on the eve of great storms, the rising movement is however the more rapid of the two. The undulations which are to be found in the curve corresponding to the intervals between the phases of the moon, often comprehend in their sweep some smaller ones, which appear to be due to occasional and less extensive causes.

It happens also from some principle of the kind above stated, that these movements, which in fair and moderate weather proceed with considerable regularity, on being disturbed by storms, are not resumed suddenly but by degrees, and the interruption is perceptible for a considerable space afterwards.

In long periods of wet weather, the barometer usually keeps about the main altitude, rising and falling through a short space with little regularity.

In serene and settled weather it is generally high; and low in calm weather, when the air is inclined to rain; it sinks on high winds, rises highest on easterly and northerly winds, and sinks when the wind blows from the south. At Calcutta, it is always highest when the wind blows from the north-west and north, and lowest when it blows from the south-east.

Such are the phenomena respecting the variations of the barometer, as far as they can be reduced under general heads. Various attempts have been made to explain them, but hitherto without any great degree of success. The theory of Mr. Kirwan appears by far the most plausible, though it is not sufficient to explain all the facts. The following observations may be considered as a kind of abstract of his theory, except in one or two instances.

It is evident, that the density of the atmosphere is least at the equator, and greatest at the poles; for at the equator, the centrifugal force, the distance from the centre of the earth, and the heat, all of which tend to diminish the density of the air, are at their maximum, while at the pole they are at their minimum. The mean height of the barometer at the level of the sea, all over the globe, is 30 inches; the weight of the atmosphere, therefore, is the same all over the globe. The weight of the atmosphere depends on its density and height: where the density of the atmosphere is greatest, its height must be least; and, on the contrary, where its density is least, its height must be the greatest. The height of the atmosphere, therefore, must be greatest at the equator, and least at the poles; and it must decrease gradually between the equator and the poles: so that its upper surface will resemble two inclined planes, meeting above the equator in their highest part.

During summer, when the sun is in our hemisphere, the mean heat between the equator and the pole does not differ so much as in winter. Indeed, the heat of northern countries at that time equals the heat of the torrid zone: thus in Russia, during July and August, the thermometer rises to 85°. Hence the rarity of the atmosphere at the pole, and consequently its height, will be increased. The upper surface of the atmosphere, therefore, in the northern hemisphere, will be less inclined, while that of the southern hemisphere, from contrary causes, will be much more inclined. The very reverse will take place during our winter.

The density of the atmosphere depends in a great measure on the pressure of the superincumbent column; and therefore decreases, according to the height, as the pressure of the superincumbent column constantly decreases. But the density of the atmosphere in the torrid zone will not decrease so fast as in the temperate and frigid zones; because its column is longer, and because there is a greater proportion of air in the higher part of this column.

This accounts for the observation of Mr. Cassan, that the barometer only sinks half as much for every 200 feet of elevation in the torrid as in the temperate zones. The density of the atmosphere at the equator, therefore, though at the surface of the earth it is less, must at a certain height equal, and at a still greater surpass, the density of the atmosphere in the temperate zones and at the poles.

A current of air is constantly ascending at the equator, and part of it at least reaches and continues in the higher parts of the atmosphere. From the fluidity of air, it is evident, that it cannot accumulate above the equator, but must roll down the inclined plane which the upper surface of the atmosphere assumes towards the poles. As the surface of the atmosphere of the northern is more inclined during our winter than that of the southern hemisphere, a greater quantity of the equatorial current of air must flow over upon the northern than upon the southern atmosphere; so that the quantity of our atmosphere will be greater during winter than that of the southern hemisphere: but during summer the very reverse will take place. Hence the greatest mercurial heights take place during winter, and the range of the barometer is less in summer than in winter.

As the heat in the torrid zone never differs much, the density, and consequently the height, of the atmosphere, will not vary much. Hence the range of the barometer within the tropics is comparatively small; and it increases gradually as we approach the poles, because the difference of the temperature, and consequently of the density, of the atmosphere, increases with the latitude.

The diurnal elevation of the barometer in the torrid zone corresponding to the tides, observed by Mr. Cassan and others, must be owing to the influence of the moon on the atmosphere. This influence, notwithstanding the ingenious attempts of D'Alembert and several other philosophers, seems altogether inadequate to account for the various phenomena of the winds. It is not so easy to account for the tendency which the barometer has to rise as the day advances, which seems to be established by Mr. Cotte's table. Perhaps it may be accounted for by the additional quantity of vapour added to the atmosphere, which, by increasing the quantity of the atmosphere, may possibly be adequate to produce the effect.

The falls of the barometer which precede, and the oscillations which accompany, violent storms and hurricanes, show us, that these phemomena are produced by very great rarefactions, or perhaps destruction of air, in particular parts of the atmosphere. The falls of the barometer, too, that accompany winds, proceed from the same cause.

That the temperature of the air varies considerably, not only in different climates and in different seasons, but even in the same place and in the same season, must be obvious to the most careless observer. This perpetual variation cannot be ascribed to the direct heat of the sun; for the rays of that luminary seem to produce no effect whatever upon air, though ever so much concentrated; but they warm the surface of the earth, which communicates its heat to the surrounding atmosphere. Hence it happens, that the temperature of the air is highest in those places which are so situated as to be most warmed by the sun's rays, and that it varies in every region with the season of the year. Hence too the reason why it diminishes according to the height of the air above the surface of the earth. That portion of the earth which lies at the equator, is exposed to the most perpendicular rays of the sun. Of course it is hottest, and the heat of the earth diminishes gradually from the equator to the poles. The temperature of the air must follow the same order. The air, then, is hottest over the equator; and its temperature gradually diminishes from the equator to the poles, where it is coldest of all. It is hottest at the surface; and it becomes gradually colder, according to its height above that surface. Let us examine the nature of these two diminishing progressions of temperature.

1. Though the temperature of the air is highest at the equator, and gradually sinks as it approaches the pole, yet as in every place the temperature of the air is constantly varying with the season of the year, we cannot form any precise notion of the progression, without taking the temperature in every degree of latitude for every day of the year, and forming from each a mean temperature for the whole year; which is done by adding together the whole observations, and dividing by their number. The quotient gives the mean temperature for the year. The diminution from the pole to the equator takes place in arithmetical progression; or, to speak more properly, the annual temperatures of all the latitudes are arithmetical means between the mean annual temperature of the equator and the pole. This was first discovered by Mr. Mayer; and by means of an equation which he founded on it, but rendered considerably plainer and simpler, Mr. Kirwan has caculated the mean annual temperature of every degree of latitude between the equator and the pole. He proceeded on the following principle: Let the mean annual heat at the equator be $m - n$; put φ for any other latitude; the mean annual temperature of that latitude will be $m - n \times \sin. \varphi^2$. If therefore the temperature of any two latitudes is known, the value of m and n may be found. Now the temperature of north latitude 40° has been found by the best observations to be 62.1°, and that of latitude 50°, 52.9°. The square of the sine of 40° is nearly 0.419, and the square of the sine of 50° is nearly 0.586. Therefore,

$m - 0.41\, n = 62.1$, and

$m - 0.58\, n = 52.9$; therefore,

$62.1 + 0.41\, n = 52.9 + 0.58\, n$; as each of them, from the two first equations, is equal to m. From this last equation the value of n is found to be 53 nearly; and m is nearly equal to 84. The mean temperature of the equator, therefore, is 84°, and that of the pole 31°. To find the mean temperature for every other latitude, we have only to find 88 arithmetical means between 84 and 31. In this manner Mr. Kirwan calculated the following table:

TABLE

Of the Mean Annual Temperature of the Standard Situation in every Latitude.

Lat.	Temper.	Lat.	Temper	Lat.	Temper.
90	31.	83	31.7	76	34.1
89	31.04	82	32.	75	34.5
88	31.10	81	32.2	74	35.
87	31.14	80	32.6	73	35.5
86	31.2	79	32.9	72	36.
85	31.4	78	33.2	71	36.6
84	31.5	77	33.7	70	37.2

Lat.	Temper.	Lat.	Temper.	Lat.	Temper.
69	37.8	47	55.6	25	74.5
68	38.4	46	56.4	24	75.4
67	39.1	45	57.5	23	75.9
66	39.7	44	58.4	22	76.5
65	40.4	43	59.4	21	77.2
64	41.2	42	60.3	20	77.8
63	41.9	41	61.2	19	78.3
62	42.7	40	62.	18	78.9
61	43.5	39	63.	17	79.4
60	44.3	38	63.9	16	79.9
59	45.09	37	64.8	15	80.4
58	45.8	36	65.7	14	80.8
57	46.7	35	66.6	13	81.3
56	47.5	34	67.4	12	81.7
55	48.4	33	68.3	11	82.
54	49.2	32	69.1	10	82.3
53	50.2	31	69.9	9	82.7
52	51.1	30	70.7	8	82.9
51	52.4	29	71.5	7	83.2
50	52.9	28	72.3	6	83.4
49	53.8	27	72.8	5	83.6
48	54.7	26	73.8	0	84.

This table, however, only answers for the temperature of the atmosphere of the ocean. It was calculated for that part of the Atlantic Ocean which lies between the 80th degree of northern and the 45th of southern latitude, and extends westward as far as the Gulf-stream, and to within a few leagues of the coast of America; and for all that part of the Pacific Ocean reaching from latitude 45° north to latitude 40° south, from the 20th to the 275th degree of longitude east of London. This part of the ocean Mr. Kirwan calls the standard; the rest of the ocean is subject to anomalies which will be afterwards mentioned.

Mr. Kirwan has also calculated the mean monthly temperature of the standard ocean. The principles on which he went were these: The mean temperature of April seems to approach very nearly to the mean annual temperature; and as far as heat depends on the action of the solar rays, the mean heat of every month is as the mean altitude of the sun, or rather as the sine of the sun's altitude. The mean heat of April, therefore, and the sine of the sun's altitude, being given, the mean heat of May is found in this manner: As the sine of the sun's mean altitude in April, is to the mean heat of April, so is the sine of the sun's mean altitude in May, to the mean heat of May. In the same manner the mean heats of June, July, and August, are found; but the rule would give the temperature of the succeeding months too low, because it does not take in the heat derived from the earth, which possesses a degree of heat equal to the mean annual temperature. The real temperature of these months, therefore, must be looked upon as an arithmetical mean between the astronomical and terrestrial heats. Thus, in latitude 51°, the astronomical heat of the month of September is 44.6°, and the mean annual heat is 52.4°; therefore the real heat of this month should be $\frac{44.6+52.4}{2} =$ 48.5. Mr. Kirwan, however, after going through a tedious calculation, found the results to agree so ill with observations, that he drew up the following table, partly from principles, and partly by studying a variety of sea journals:

TABLE of the Monthly Mean Temperature of the Standard from Lat. 80° to Lat. 10°.

Lat.	80°	79°	78°	77°	76°	75°	74°	73°	72°	71°	70°	69°	68°	67°	66°	65°	64°	63°
January	22.	22.5	23.	23.5	24.	24.5	25.	25.5	26.	26.5	27.	27.5	27.5	28.	28.	28.	29.	30.
February	23.	23.	23.5	24.	24.5	25.	25.5	26.	26.5	27.	27.5	28.	28.	28.5	29.	30.	31.	32.
March	27.	27.5	28.	28.5	29.	29.5	30.	30.5	31.	31.5	32.	32.5	33.	33.5	34.	35.	36.	37.
April	32.6	32.9	33.2	33.7	34.1	34.5	35.	35.5	36.	36.6	37.2	37.8	38.4	39.1	39.7	40.4	41.2	41.9
May	36.5	36.5	37.	37.5	38.	38.5	39.	39 5	40.	40.5	41.	41.5	42.	42.5	43.	44.	45.	46.
June	51.	51.	51.5	52.	52.	52.	52.5	53.	53.5	54.	54.	54.5	54.5	54.5	55.	55.	55.5	55.5
July	50.	50.	50.5	51.	51.	51.	51.5	52.	52.5	53.	53.5	53.5	53.5	54.	54 5	54.5	55.	55.
August	39.5	40.	41.	41.5	42.	42.5	43.	43.5	44.	44.5	45.	45.5	46.	47.	48.	48.5	49.	50.
September	33.5	34.	34.5	35.	35.5	36.	36.5	37.	38.	38.5	39.	39.5	40.	41.	42.	43.	44.	45.
October	28.5	29.	29.5	30.	30.5	31.	31.5	32.	32.5	33.	33.5	34	34.	35.	36.	37.	37.5	38.
November	23.	23.5	24.	24.5	25.	25.5	26.	26.5	27.	27.5	28.	28.5	29.	30.	31.	32.	32.5	33.
December	22.5	23.	23.5	24.	24.5	25.	25.5	26.	26.5	27.	27.5	28.	28.	29.	30.	30.5	31.	31.

Lat.	62°	61°	60°	59°	58°	57°	56°	55°	54°	53°	52°	51°	50°	49°	48°	47°	46°	45°
January	31.	32.	33.	34.	35.	36.	37.	38.	39.	40.	41.	42.	42.5	43.5	43.	42.5	44.	44.5
February	33.	34.	35.	36.	37.	38.	39.	40.	41.	42.	43.	44.	44.5	44.5	45.	45.5	46.	46.5
March	38.	39.	40.	41.	42.	43	44.6	45.	46.	48.	49.	50.	50.5	51.	52.5	53.	53.5	54.5
April	42.7	43.5	44.3	45.09	45.8	46.7	47.5	48.4	49.2	50.2	51.1	52.4	52.9	53.8	54.7	55.6	56.4	57.5
May	47.	48.	49.	50.	51.	52	53.	54.	55.	56.	57.	58.	58.5	59.	60.	61.	62.	63.
June	56.	56.	56.	56.5	57.	57.	57.5	58.	58.5	59.	59.	60.	61.	62.	63.	64.	65.	66.
July	55.5	55.5	56.	56.5	57.	56.5	58.	59.	60.	61.	62.	63.	63.5	64.	65.	66.	67.	68.
August	51.	52.	53.	54.	55	55.	57.	58.	59.	60.	61.	62.	63.5	64.	65.	66.	67.	68.
September	46.	47.	48.	49.	50.	51.	52.	53.	54.	55.	56.	57.	58.5	59.	60.	61.	62.	63.
October	39.	40.	41.	42.	43.	44.	45.	46.	47.	48.	49.	50.	50.5	51.	52.	53.	54.	55.
November	34.	35	36.	37.	38.	39.	40.	41.	42.	43.	44.5	46.	46.5	47.	48.	49.	50.	51.
December	32.	33.	34.	35.	36.	37.	38.	39.	40.	41.	42.	44.	44.5	45.	46.	47.	48.	49.

Lat.	44°	43°	42°	41°	40°	39°	38°	37°	36°	35°	34°	33°	32°	31°	30°	29°	28°	27°
January	45.	45.5	46.	46.5	49.5	51.	52.	53.5	55.	56.	59.5	63.	63.	63.	63.5	63.5	63.5	64.
February	47.	48.	49.	50.	53.	56.5	58.	60.	61.	62.	63.	64.5	66.	67.	68.5	68.5	69.5	69.5
March	55.5	56.5	58.5	59.5	60.	60.5	61.	62.	63.	64.	65.	66.5	67.5	68.5	69.5	71.	72.	72.5
April	58.4	59.4	60.3	61.2	62.1	63.	63.9	64.8	65.7	66.7	67.4	68.3	69.1	69.9	70.7	71.5	72.3	72 8
May	64.	65.	66.	67.	68.	69.	70.	70.5	71.	71.	72.	72.5	73.	73	73.5	74.5	75.5	76.
June	67.	68.	69.	70.	70.5	71.	71.	71.	71.5	71.5	72.	72.5	73.	73.	73.5	74.5	75.5	76.
July	69.	69.5	70.	70.	71.	71.	72.	72.	72.5	72.5	72.5	72.5	73.	73.	73.5	74.5	75.5	76.
August	69.	69.5	70.	70.	71.	71.	72.	72.	72.5	72.5	72.5	72.5	73.	73.	73.5	74.5	75.5	76.
September	64.	66.	68.	69.5	70.5	71.	71.5	72.	72.5	72.5	72.5	72.5	73.	73.	73.5	74.	75.5	76.
October	56.	57.	58.	59.	60.	61.	62.	63.	64.	65.	66.	67.5	68.5	69.5	70.5	71.	72.5	72.5
November	52.	53.	54.	55.	56.	57.	58.	59.	60.	61.	62.	63.	64.5	65.5	66.5	68.	69.	69.5
December	50.	51.	52.	53.	54.	55.	56.	57.	58.	59.	60.	61.	62.5	63.5	64.5	66.	67.	67.5

Lat.	26°	25°	24°	23°	22°	21°	20°	19°	18°	17°	16°	15°	14°	13°	12°	11°	10°
January	64.5	65.5	67.	68.	69.	71.	72.	72.5	73.	73.5	74.	74.5	75.	76.	76.5	77.	77.5
February	70.5	71.	72.	72.	72.5	74.	75.	76.	76.5	77.	77.5	78.	78.5	79.	79.5	79.8	80.
March	73.	73.5	74.5	75.	75.5	76.	77.	77.5	78.	78.5	79.	79.5	80.	80.8	81.	81.5	81.8
April	73.8	74.5	75.4	75.9	76.5	77.2	77.8	78.3	78.9	79.4	79.9	80.4	80.8	81.3	81.7	82.	82.3
May	76.5	77.5	78.	78.5	79.5	80.	80.5	81.	81.5	82.	82.5	83.	83.	83.5	84.	84.	84.3
June	76.5	78.	78.5	79.	79.5	80.	80.5	81.5	82.	82.5	83.	83.5	83 8	84.	84.3	84.6	84.8
July	76.5	78.	78.5	79.	79 5	80.	80.5	81.5	82.	82.5	83.	83.5	83.8	84.	84.3	84.6	84.8
August	76.5	78.	78.5	79.	79.5	80.	80.5	81.5	82.	82.5	83.	83.5	83.8	84.	84.3	84.6	84.8
September	76.5	77.5	78.	78.5	79.	79.5	80.	81.	81.5	82.	82.5	83.	83.	83.5	84.	84.3	84.6
October	73.	73.5	74.5	75.	75.5	77.	78.	79.	80.	81.	81.5	82.	82.5	83.	83.5	83.8	84.
November	71.5	72.	73.5	74.	74.5	75.	75.5	76.	77.	78.	78.5	79.	79.5	80.	80.5	80.8	81.
December	68.5	69.5	70.	71.	71.5	72.	72.5	73.	74.	75.	75.5	76.	76.	77.	77.5	78.	78.5

From this table it appears, that January is the coldest month in every latitude, and that July is the warmest month in all latitudes above 48°. In lower latitudes, August is generally warmest. The difference between the hottest and coldest months increases in proportion to the distance from the equator. Every habitable latitude enjoys a mean heat of 60° for at least two months; this heat seems necessary for the production of corn. Within 10° of the poles, the temperatures differ very little; neither do they differ much within 10° of the equator: the temperatures of different years differ very little near the equator; but they differ more and more as the latitudes approach the poles.

2. That the temperature of the atmosphere gradually diminishes, according to its height above the level of the sea, is well known. Thus the late Dr. Hutton, of Edinburgh, found, that a thermometer, kept on the top of Arthur's-seat, usually stood three degrees lower than a thermometer kept at the bottom of it. Hence, then, a height of 800 feet occasioned 3° of diminution of temperature. On the summit of Pinchinca, the thermometer stood at 30°, as observed by Bouguer; while at the level of the sea, in the same latitude, it stood at 84°. Here a height of 15564 feet occasioned a diminution of temperature, amounting to 54°. But though there can be no doubt of the gradual diminution of temperature, according t. the height, it is by no means easy to determine the rate of diminution. Euler supposes it to be in a harmonic progression; but this opinion is contradicted by observations. Saussure supposes, that in temperate climates the diminution of temperature amounts to 1° for every 287 feet of elevation. But Mr. Kirwan has shown that no such rule holds, and that the rate of diminution varies with the temperature at the surface of the earth. We are indebted to this philosopher for a very ingenious method of determining the rate of the diminution in every particular case, supposing the temperature at the surface of the earth known.

Since the temperature of the atmosphere is constantly diminishing as we ascend above the level of the sea, it is obvious, that at a certain height we arrive at the region of perpetual congelation. This region varies in height according to the latitude of the place; it is highest at the equator, and descends gradually nearer the earth as we approach the poles. It varies also according to the season, being highest in summer, and lowest in winter. M. Bouguer found the cold on the top of Pinchinca, one of the Andes, to extend from seven to nine degrees below the freezing-point every morning immediately before sunrise. He concluded, therefore, that the mean height of the term of congelation (the place where it freezes during some part of the day all the year round) between the tropics was 15,577 feet above the level of the sea; but in latitude 28° he placed it in summer at the height of 13,440 feet. Now, if we take the difference between the temperature of the equator and the freezing-point, it is evident that it will bear the same proportion to the term of congelation at the equator, that the difference between the mean temperature of any other degree of latitude and the freezing-point bears to the term of congelation in that latitude. Thus the mean heat of the equator being 84°, the difference between it and 32 is 52; the mean heat of latitude 28° is 72.3°; the difference between which and 32 is 40.3: then 52 : 15577 : : 40.3 : 12072. In this manner Mr. Kirwan calculated the following table:

Lat.	Mean height of the term of congelation *Feet.*
0	15577
5	15457
10	15067

15 - - - -	14498
20 - - - -	13719
25 - - - -	13030
30 - - - -	11592
35 - - - -	10664
40 - - - -	9016
45 - - - -	7658
50 - - - -	6260
55 - - - -	4912
60 - - - -	3684
65 - - - -	2516
70 - - - -	1557
75 - - - -	748
80 - - - -	120

Beyond this height, which has been called the lower term of congelation, and which must vary with the season and other circumstances, Mr. Bouguer has distinguished another, which he called the upper term of congelations; that is, the point above which no visible vapour ascends. Mr. Kirwan considers this line as much less liable to vary during the summer months than the lower term of congelation, and therefore has made choice of it to determine the rate of the dimunition of heat, as we ascend in the atmosphere. Bouguer determined the height of this term in a single case, and Kirwan has calculated the following table of its height for every degree of latitude in the northern hemisphere:

TABLE

Of the Height of the Upper Line of Congelation in the different Latitudes of the Northern Hemisphere.

N. Lat.	Feet.	N. Lat	Feet.	N. Lat.	Feet.
0°	28000	33	19800	62	4989
5	27784	34	19454	63	4910
6	27644	35	19169	64	4831
7	27504	36	18577	65	4752
8	27364	37	17985	66	4684
9	27224	38	17393	67	4616
10	27084	39	16801	68	4548
11	26880	40	16207	69	4480
12	26676	41	15712	70	4413
13	26472	42	15217	71	4354
14	26268	43	14722	72	4295
15	26061	44	14227	73	4236
16	25781	45	13730	74	4177
17	25501	46	13235	75	4119
18	25221	47	12740	76	4067
19	24941	48	12245	77	4015
20	24661	49	11750	78	3963
21	24404	50	11253	79	3911
22	24147	51	10124	80	3861
23	23890	52	8965	81	3815
24	23633	53	7806	82	3769
25	23423	54	6647	83	3723
26	22906	55	5617	84	3677
27	22389	56	5533	85	3631
28	21872	57	5439	86	3592
29	21355	58	5345	87	3553
30	20838	59	5251	88	3514
31	20492	60	5148	89	3475
32	20146	61	5068	90	3432

The following rule of Mr. Kirwan will enable us to ascertain the temperature at any required height, provided we know the temperature at the surface of the earth.

Let the observed temperature at the surface of the earth be $=m$, the height given $=h$, and the height of the upper term of congelation for the given latitude be $=t$; then $\dfrac{m-32}{\frac{t}{100}-1}$ = the diminution of temperature for every hundred feet of elevation; or it is the common difference of the terms of the progression required. Let this common difference thus found be denoted by c; then $c \times \dfrac{h}{100}$ gives us the whole diminution of temperature from the surface of the earth to the given height. Let this diminution be denoted by d, then $m-d$ is obviously the temperature required. An example will make this rule sufficiently obvious. In latitude 56°, the heat below being 54°, required the temperature of the air at the height of 803 feet?

Here then $m=54$, $t=5533$, $\dfrac{m-32}{\frac{t}{100}-1} = \dfrac{22}{54.33} = 0.404$ $= c$, and $c \times \dfrac{h}{100} = 0.404 \times 8.03 = 3.24 = d$, and $m-d$ $= 54 - 3.24 = 50.75$. Here we see that the temperature of the air 803 feet above the surface of the earth is 50°.75.

From this method of estimating the diminution of temperature, which agrees remarkably well with observation, we see that the heat diminishes in an arithmetical progression. Hence it follows, that the heat of the air at a distance from the earth is not owing to the ascent of hot strata of air from the surface of the earth, but to the conducting power of the air.

3. This rule, however, applies only to the temperature of the air during the summer months of the year. In winter the upper strata of the atmosphere are often warmer than the lower. Thus, on the 31st of January, 1776, the thermometer on the summit of Arthur's-seat stood six degrees higher than a thermometer at Hawkhill, which is 684 feet lower. Mr. Kirwan considers this superior heat, almost uniformly observed during winter, as owing to a current of warm air from the equator, which rolls towards the north pole during our winter.

4. Such, then, in general is the method of finding the mean annual temperature over the globe. There are, however, several exceptions to these general rules, which come now to be mentioned.

That part of the Pacific Ocean which lies between north latitudes 52° and 66°, is no broader at its northern extremity than 42 miles, and at its southern extremity than 1300 miles: it is reasonable to suppose, therefore, that its temperature will be considerably influenced by the surrounding land, which consists of ranges of mountains covered a great part of the year with snow; and there are besides a great many high, and consequently cold, islands scattered through it. For these reasons Mr. Kirwan concludes, that its temperature is at least four or five degrees below the standard. But we are not

yet furnished with a sufficient number of observations to determine this with accuracy.

It is the general opinion, that the southern hemisphere, beyond the 40th degree of latitude, is considerably colder than the corresponding parts of the northern hemisphere. Mr. Kirwan has shown that this holds with respect to the summer of the southern hemisphere, but that the winter in the same latitudes is milder than in the northern hemisphere.

Small seas surrounded with land, at least in temperate and cold climates, are generally warmer in summer and colder in winter than the standard ocean, because they are a good deal influenced by the temperature of the land. The gulf of Bothnia, for instance, is for the most part frozen in winter; but in summer it is sometimes heated to 70°, a degree of heat never to be found in the opposite part of the Atlantic. The German Sea is above three degrees colder in winter, and five degrees warmer in summer, than the Atlantic. The Mediterranean Sea is, for the greater part of its extent, warmer both in summer and winter than the Atlantic, which therefore flows into it. The Black Sea is colder than the Mediterranean, and flows into it.

The eastern parts of North America are much colder than the opposite coast of Europe, and fall short of the standard by about 10° or 12°, as appears from American meteorological tables. The causes of this remarkable difference are many. The highest part of North America lies between the 40th and 50th degree of north latitude, and the 100th and 110th degree of longitude west from London; for there the greatest rivers originate. The very height, therefore, makes this spot colder than it otherwise would be. It is covered with immense forests, and abounds with large swamps and morasses, which render it incapable of receiving any great degree of heat; so that the rigour of winter is much less tempered by the heat of the earth than in the old continent. To the east lie a number of very large lakes; and farther north, Hudson's-Bay; about 50 miles on the south of which there is a range of mountains, which prevent its receiving any heat from that quarter. This bay is bounded on the east by the mountainous country of Labrador, and by a number of islands. Hence the coldness of the north-west winds, and the lowness of the temperature. But as the cultivated parts of North America are now much warmer than formerly, there is reason to expect that the climate will become still milder when the country is better cleared of woods, though perhaps it will never equal the temperature of the old continent.

Islands are warmer than continents in the same degree of latitude; and countries lying to the windward of extensive mountains or forests are warmer than those lying to the leeward. Stones or sand have a less capacity for heat than earth has, which is always somewhat moist; they heat or cool, therefore, more rapidly and to a greater degree. Hence the violent heat of Arabia and Africa, and the intense cold of Terra del Fuego. Living vegetables alter their temperature very slowly, but their evaporation is great; and if they are tall and close, as in forests, they exclude the sun's rays from the earth, and shelter the winter snow from the wind and the sun. Woody countries, therefore, are much colder than those which are cultivated.

Air is one of those bodies which have received the name of electric, because they are capable of being positively or negatively charged with electric matter. It not only contains that portion of electricity which seems necessary to the constitution of all terrestrial bodies, but it is liable also to be charged negatively or positively when electricity is abstracted or introduced by means of conducting bodies. These different states must occasion a variety of phenomena, and in all probability contribute very considerably to the various combinations and decompositions which are continually going on in air. The electrical state of the atmosphere, then, is a point of considerable importance, and has with great propriety occupied the attention of philosophers ever since Dr. Franklin demonstrated that thunder is occasioned by the agency of electricity.

1. The most complete set of observations on the electricity of the atmosphere were made by professor Beccaria of Turin. He found the air almost always positively electrical, especially in the day-time and in dry weather. When dark or wet weather clears up, the electricity is always negative. Low thick fogs rising into dry air carry up a great deal of electric matter.

2. In the morning, when the hygrometer indicates dryness equal to that of the preceding day, positive electricity obtains even before sunrise. As the sun gets up, this electricity increases more remarkably if the dryness increases. It diminishes in the evening.

3. The mid-day electricity of days equally dry is proportional to the heat.

4. Winds always lessen the electricity of a clear day, especially if damp.

5. For the most part, when there is a clear sky with little wind, a considerable electricity arises after sunset at dew-falling.

6. Considerable light has been thrown upon the sources of atmospherical electricity by the experiments of Saussure and other philosophers. Air is not only electrified by friction, like other electric bodies, but the state of its electricity is changed by various chemical operations which often go on in the atmosphere. Evaporation seems in all cases to convey electric matter into the atmosphere. On the other hand, when steam is condensed into water, the air becomes negatively electric.

Farther, Mr. Canton has ascertained that dry air, when heated, becomes negatively electric, and positive when cooled, even when it is not permitted to expand or contract: and the expansion and contraction of air also occasion changes in its electric state.

Thus there are four sources of atmospheric electricity known: 1. Friction; 2. Evaporation; 3. Heat and cold; 4. Expansion and contraction: not to mention the electricity evolved by the melting, freezing, solution, &c. of various bodies in contact with air.

7. As air is an electric, the matter of electricity, when accumulated in any particular strata, will not immediately make its way to the neighbouring strata, but will induce in them changes similar to what is induced upon plates of glass or similar bodies piled upon each other. Therefore, if a stratum of air is electrified positively, the stratum immediately above it will be negative, the stratum above that positive, and so on. Suppose now that an imperfect conductor was to come into contact with each

of these strata: we know from the principles of electricity that the equilibrium would be restored, and that this would be attended with a loud noise, and with a flash of light. Clouds are imperfect conductors; if a cloud, therefore, comes into contact with two such strata, a thunderclap will follow. If a positive stratum is situated near the earth, the intervention of a cloud will, by serving as a stepping-stone, bring the stratum within the striking distance, and a thunderclap will be heard while the electrical fluid is discharging itself into the earth. If the stratum is negative, the contrary effects will take place. It does not appear, however, that thunder is often occasioned by a discharge of electric matter from the earth into the atmosphere. The accidents, most of them at least, which were formerly ascribed to this cause, are now much more satisfactorily accounted for by lord Stanhope's theory of the returning stroke. The discharge from the clouds directly into the earth is also probably less frequent than from cloud to cloud.

The far greater part of the visible phenomena of the atmosphere are due to the water which, being raised by evaporation, is transported from place to place in vapour, and which, physically speaking, is a proper component part of the air. When by any means a portion of this is deprived of its constituent caloric, it reappears in minute drops, which are at first uniformly diffused, and lessen the transparency of the air in proportion to their abundance. By the report of those who have ascended the highest mountains, or performed ærostatic voyages, there is usually a sufficient quantity of this diffused water, especially towards evening, to become visible from above as a sea of haze. It should seem that this is, in fact, the veil which, being drawn over the sable of the sky, converts it to a blue of various degrees of intensity; or at least that it shares with the transparent air in this effect.

The next stage is dew, or rather haze, for the latter term seems more appropriate to the appearance of dew while it is falling. Here the drops have so far become collected as to form an aggregate faintly defined in the air. To this succeed various definite aggregates, under the general term cloud. Out of the latter are formed rain, snow, and hail, by which the product of evaporation is finally restored to the earth. The excess for any given time, of the falling water over that which is evaporated, passes off by the springs and rivers to that grand reservoir which forms the far greater part of the surface of the globe.

Tracts of forests, especially if mountainous, invite the rain, and protect the springs; while the accumulated heat on cultivated plains often causes the clouds to pass over them, or to be dissipated. Clearing of land and culture, therefore, tend to lessen the rain and the rivers; but it is for the interest of agriculture to leave a certain quantity of timber growing, especially in springy lands, and to repair the waste of it by planting; for it is not impossible, that in a series of ages, the axe and the plough too freely applied might convert a tract of fruitful country into one little better than an African desert.

The mean annual quantity of rain is greatest at the equator, and decreases gradually as we approach the poles. Thus at

Granada, Antillis,	12°	N. lat. it is	126 inches
Cape François, St. Domingo -	19° 46′	-	120
Calcutta -	22 23	-	81
Rome - -	41 54	-	39
England - -	53	-	32
Petersburgh -	59 16	-	16

On the contrary, the number of any days is smallest at the equator, and increases in proportion to the distance from it. From north latitude 12° to 43°, the mean number of rainy days is 78; from 43° to 46° the mean number is 103; from 46° to 50° it is 134; from 50° to 60°, 161.

The number of rainy days is often greater in winter than in summer; but the quantity of rain is greater in summer than in winter. At Petersburgh the number of rainy or snowy days during winter is 84, and the quantity which falls is only about five inches; during summer the number of rainy days is nearly the same, but the quantity which falls is about 11 inches.

More rain falls in mountainous countries than in plains. Among the Andes it is said to rain almost perpetually; while in Egypt it hardly ever rains at all. If a rain-guage is placed on the ground, and another at some height perpendicularly above it, more rain will be collected into the lower than into the higher; a proof that the quantity of rain increases as it descends, owing perhaps to the drops attracting vapour during their passage through the lower strata of the atmosphere where the greatest quantity resides. This, however, is not always the case, as Mr. Copland of Dumfries discovered in the course of his experiments. He observed also, that when the quantity of rain collected into the lower gague was greatest, the rain commonly continued for some time; and that the greatest quantity was collected in the higher gauge only either at the end of great rains, or during rains which did not last long. These observations are important; and may, if followed out, give us new knowledge of the cause of rain. They seem to show, that during rain the atmosphere is somehow or other brought into a state which induces it to part with its moisture; and that the rain continues as long as this state continues. Were a sufficient number of observations made on this subject in different places, and was the atmosphere carefully analysed during dry weather, during rain, and immediately after rain, we might soon perhaps discover the true theory of rain.

Rain falls in all seasons of the year, at all times of the day, and during the night as well as the day; though, according to M. Toaldo, a greater quantity falls during the day than the night. The cause of rain then, whatever it may be, must be something which operates at all times and seasons. Rain falls also during the continuance of every wind, but oftenest when the wind blows from the south. Falls of rain often happen likewise during perfect calms.

It appears from a paper published by M. Cotte in the Journal de Physique for Oct. 1791, containing the mean quantity of rain falling at 147 places situated between north lat. 11° and 60°, deduced from tables kept at these places, that the mean annual quantity of rain falling in all these places is 34.7 inches. Let us suppose then (which cannot be very far from the truth) that the

mean annual quantity of rain for the whole globe is thirty-four inches. The superficies of the globe consists of 170,981,012 square miles, or 686,401,498,471,475,200, square inches. The quantity of rain therefore falling annually will amount to 23,337,650,812,030,156,800 cubic inches, or somewhat more than 91,751 cubic miles of water.

The dry land amounts to 52,745,253 square miles; the quantity of rain falling on it annually therefore will amount to 30,960 cubic miles. The quantity of water running annually into the sea is 13,140 cubic miles; a quantity of water equal to which must be supplied by evaporation from the sea, otherwise the land would soon be completely drained of its moisture.

The quantity of rain falling annually in Great Britain may be seen from the following table: which is probably the most extensive of the kind; and as accurate as the use of instruments, not constructed by one person and adjusted to a common standard, will allow. It is mostly compiled from the Transactions of different learned societies.

Counties (maritime).	Places.	Mean ann. depth in inches.
Cumberland.	Keswick, 7 years - -	67. 5
	Carlisle, 1 year - - -	20. 2
Westmoreland.	Kendal, 11 years - -	59. 8
	Fell-foot, 3 years - -	55. 7
	Waith Sutton, 5 years -	46
Lancashire.	Lancaster, 10 years - -	45
	Liverpool, 18 years - -	34. 4
	Manchester, 9 years - -	33
	Townley - - - -	41
	Crawshawbooth, near Haslingden, 2 years - - -	60
Gloucestershire.	Bristol, 3 years - -	29. 2
Somersetshire.	Bridgewater, 3 years -	29. 3
Cornwall.	Ludguan, near Mount's Bay, 5 years - - - -	41
	Another place, 1 year -	29. 9
Devonshire.	Plymouth, 2 years - -	46. 5
Hampshire.	Selbourne, 9 years - -	37. 2
	Fyfield, 7 years - -	25. 9
Kent.	Dover, 5 years - -	37. 5
Essex.	Upminster - -	19. 5
Norfolk.	Norwich, 13 years - -	25. 5
Yorkshire.	Barrowby, near Leeds, 6 years	27. 5
	Garsdale, near Sedbergh, 3 years	52. 3
Northumberland	Widdrington, 1 year -	21. 2
Counties (inland).	**Places.**	**Means.**
Middlesex.	London, 7 years - -	23.
Surry.	South Lambeth, 9 years -	22. 7
Hertfordshire.	Near Ware, 5 years - -	25
Huntingdonsh.	Kimbolton, 7 years - -	25
Derbyshire.	Chatsworth, 15 years -	27. 8
Rutlandshire.	Lyndon, 21 years -	24. 3
Northamptonsh.	Near Oundle, 14 years -	23
	General mean -	35. 2

As the places subject to much rain predominate considerably in this list, it will probably be nearer the truth, if we take the mean annual rain in England and Wales at a quantity not exceeding 32 inches.

In this country it generally rains less in March than in November, in the proportion at a medium of 7 to 12. It generally rains less in April than October in the proportion of 1 to 2 nearly at a medium. It generally rains less in May than September; the chances that it does so are at least 4 to 3: but when it rains plentifully in May (as 1.8 inches or more), it generally rains but little in September; and when it rains one inch or less in May, it rains plentifully in September.

Snow is evidently formed by a process of regular crystallization among minute frozen particles of water floating in the air. It is remarkable, that previous to. and during, the fall of snow in quantity, the temperature continues about 32°. It should seem that the evolution of the constituent caloric of the water produces the same effect when ice is formed in the atmosphere, as when it is formed in water. The structure of a crystal of snow demonstrates that a drop of rain is also formed by the union of a great number of smaller drops. When these come together in the act of freezing, and suddenly, they form a nucleus of white spongy ice, which, by its extreme coldness, becoming incrusted with clear ice from the water it collects in its descent, constitutes hail as we usually see it. Sometimes, however, the nucleus falls unincrusted, which is a prognostic of sharp frosts. Hail has been likewise observed perfectly transparent, and having the form of an oblate spheroid, showing that it consisted of drops which had been frozen entire in falling with a rotatory motion.

The forms assumed by the suspended water in the interval between the first precipitation and the descent of rain, afford a copious field of observation. These are not, as might be hastily supposed, the sport of winds, changing with every movement of the containing medium. Indeed the atmosphere, at the height where clouds usually appear, is undisturbed by the various obstacles which throw it into contending streams and eddies near the surface of the earth, and flows in a more direct and even current. Accordingly, the particles of water which it contains are allowed to assume a certain arrangement; and constitute a form which is often equally well defined at a distance with that of solids, although, were we to penetrate it, we should perceive only the grey mist.

These forms have lately been discovered to be subject to certain laws in their production, their action on each other, and their resolution into rain. The visible course of these has been traced and described; and the ancient mode of drawing prognostics seems in consequence likely to be restored, with the advantage of a nomenclature, by which the learned may reason on a subject hitherto, for want of terms, in a manner incommunicable, and confined to the adepts of experience. Before the nomenclature, it will be proper to exhibit the general principles on which its author proceeds in his explanation of the facts.

Evaporation is not a process of solution in air, neither is it probable that the water is decomposed by it. It is the same procession in the great scale of nature, as in a small quantity of water placed over the fire. Vapour is formed and diffused in all directions from its source with a force proportioned to the temperature of the water, and subject to the opposing force of the vapour already in the air.

The vapour thus emitted may be decomposed in dif-

ferent ways; as 1. Immediately on its passing into the atmosphere, producing a fog or mist. 2. After having mounted through the warm air, near the earth, on its arrival in a higher and colder region, in which case dense clouds are there formed. 3. After having been uniformly mixed with the mass of the atmosphere, and perhaps travelled with it to a great distance from its source; in this case it either falls in dew, or is collected into sheets or horizontal beds during a slower subsidence; or lastly, it becomes a conductor to the electricity, if the equilibrium of the latter is disturbed; and indicates by its arrangement in threads, the usual effects of that fluid on light bodies.

In every case, the caloric which constituted the vapour decomposed, appears to pass into the atmosphere, which hence becomes often sensibly warmer just before rain; and on the other hand, the evaporation of the water suspended in the air, robs it of so much as to become sensible to our feelings in its comparative coldness.

The predisposing causes of these changes near the earth are probably to be found in the state of the superior currents, which undoubtedly both impart and carry off great quantities of vapour; but this part of the subject is at present imperfectly provided with such observations as might serve for data to our reasoning.

There are three simple and distinct modifications, in any one of which the aggregate of minute drops, called a cloud, may be formed, increase to its greatest extent, and finally decrease and disappear.

By modification is to be understood simply the structure or manner of aggregation, not the precise form or magnitude, which indeed varies every moment in most clouds. The principal modifications are commonly as distinguishable from each other as a tree from a hill, or the latter from a lake; although clouds in the same modification, considered with respect to each other, have often only the common resemblances which exist among trees, hills, or lakes, taken generally.

The same aggregate, which has been formed in one modification, upon a change in the attendant circumstances may pass into another.

Or it may continue a considerable time in an intermediate state, partaking of the characters of two modifications; and it may also disappear in this stage, or return to the first modification. Lastly, aggregates, separately formed in different modifications, may unite and pass into one, exhibiting different characters in different parts; or a portion of a simple aggregate may pass into another modification, without separating from the remainder of the mass. Hence, together with the simple, it becomes necessary to admit intermediate and compound modifications, and to impose names on such of them as are worthy of notice.

The simple modifications are thus named and defined: (See Plate LXXXV Meteorology.)

1. *Cirrus.* Def. Nubes cirrata, tenuissima, quæ undique crescat.

Parallel, flexuous, or diverging fibres, extensible in any or in all directions.

2. *Cumulus.* Def. Nubes cumulata, densa, sursum crescens.

Convex or conical heaps, increasing upward from a horizontal base.

3. *Stratus.* Def. Nubes strata, aquæ modo expansa, deorsum crescens.

A widely extended, continuous, horizontal sheet, increasing from below.

The intermediate modifications which require to be noticed are:

4. *Cirro-cumulus.* Def. Nubeculæ densiores, subrotundæ, et quasi in agmine appositæ.

Small, well defined, roundish masses, in close horizontal arrangement.

5. *Cirro-stratus.* Def. Nubes extenuata, subconcava vel undulata. Nubeculæ hujusmodi appositæ.

Horizontal or slightly inclined masses, attenuated towards a part or the whole of their circumference, concave downward; or undulated, separate, or in groups, consisting of small clouds, having these characters.

The compound modifications are:

6. *Cumulo-stratus.* Def. Nubes densa, basim cumuli cum structura patente exhibens.

A dense cloud with the base of the cumulus, but in its upper part extended into a broad flat structure.

7. *Cumulo-cirro-stratus, vel nimbus.* Def. Nubes vel nubium congeries pluviam effundens.

The rain cloud. A cloud, or system of clouds, from which rain is falling. It is a horizontal sheet, above which the cirrus spreads, while the cumulus enters it laterally, and from beneath.

Of the cirrus.

Clouds in this modification have the least density, the greatest elevation, and the greatest variety of extent and direction. They are the earliest appearance after serene weather. They are first indicated by a few threads pencilled, as it were, on the sky. These increase in length, and new ones are in the mean time added laterally. Often the first-formed threads serve as stems to support numerous branches, which in their turn give rise to others. The process may be compared either to vegetation or to crystallization; but it is clearly analogous to the delicate arrangements which ensue in the particles of coloured powders, such as chalk, vermilion, &c. when these are projected on a cake of wax, after it has been touched with the knob of a charged Leyden phial. We may consider the particles of water as similarly placed upon or beneath a plate of charged air.

Their duration is uncertain, varying from a few minutes after the first appearance to an extent of many hours. It is long when they appear alone, and at great heights, and shorter when they are formed lower, and in the vicinity of other clouds.

This modification, although in appearance almost motionless, is intimately connected with the variable motions of the atmosphere. Considering that clouds of this kind have long been deemed a prognostic of wind, it is extraordinary that the nature of this connection should not have been more studied, as the knowledge of it might have been productive of useful results.

In fair weather, with light variable breezes, the sky is seldom quite clear of small groups of the oblique cirrus, which frequently come on from the leeward, and the direction of their increase is to windward. Continued wet weather is attended with horizontal sheets of this cloud, which subside quickly, and pass to the cirro-stra-

tus. The cirrus pointing upward is a distant indication of rain, and downward a more immediate one of fair weather. Before storms they appear lower and denser, and usually in the quarter opposite to that from which the storm arises. Steady high winds are also preceded and attended by streaks running quite across the sky in the direction they blow in. These, by an optical deception, appear to meet in the horizon.

The relation of this modification with the state of the barometer, thermometor, hygrometer, and electrometer, have not yet been attended to.

Of the cumulus.

Clouds in this modification are commonly of the most dense structure. They are formed in the lower atmosphere, and move along with the current which is next the earth.

A small irregular spot first appears, and is as it were the nucleus on which they increase. The lower surface continues irregularly plane, while the upper rises into conical or hemispherical heaps.

Their appearance, increase, and disappearance, in fair weather, are often periodical, and keep pace with the temperature of the day. Thus they begin to form some hours after sunrise, arrive at the maximum in the hotest part of the afternoon, then go on diminishing, and totally disperse about sunset.

But in changeable weather they partake of the vicissitudes of the atmosphere; sometimes evaporating almost as soon as formed, at others suddenly forming, and as quickly passing to the compound modifications.

The cumulus of fair weather has a moderate elevation and extent, and a well-defined rounded surface. Previous to rain it increases more rapidly, appears lower in the atmosphere, and with its surface full of loose fleeces or protuberances.

The formation of large cumuli to leeward in a strong wind, indicates the approach of a calm with rain. When they do not disappear or subside about sunset, but continue to rise, thunder is to be expected in the night.

Independantly of the beauty and magnificence it adds to the face of nature, the cumulus serves to screen the earth from the direct rays of the sun; by its multiplied reflections to diffuse, and, as it were, economise the light; and also to convey the product of evaporation to a distance from the place of its origin. The relations of the cumulus, with the state of the barometer, &c. have not yet been enough attended to.

It appears that there is a continual evaporation from the base of this cloud, in consequence of its tendency to subside into lower and warmer air. This evaporation is more than compensated during its increase by the deposition from above: while the two effects balance each other, the cloud remains stationary as to bulk; when the supply from above fails, it sinks into the lower air, and totally dissappears. This happens usually before sunset, because the inequality in the temperatures of the higher and lower air, by virtue of which it subsisted, gives place at that time to the tendency to equal diffusion of the caloric.

Of the stratus.

This modification has a mean degree of density. It is the lowest of clouds, since its inferior surface commonly rests on the earth or water.

Contrary to the last, which may be considered as belonging to the day, this is properly the cloud of night; the time of its first appearance being about sunset. It comprehends all those creeping mists which in calm evenings ascend in spreading sheets, like an inundation of water, from the bottom of valleys, and the surface of lakes, rivers, &c. Its duration is frequently through the night.

On the return of the sun, the level surface of this cloud begins to put on the appearance of cumulus, the whole at the same time separating from the ground. The continuity is next destroyed, and the cloud ascends and evaporates, or passes off with the appearance of the nascent cumulus.

This has been long experienced as a prognostic of fair weather;

At nebulæ magis ima petunt, campoque recumbunt:—
Virgil. Georg. lib. i.

and, indeed, there is none more serene than that which is ushered in by it. The relation of the stratus to the state of the atmosphere as indicated by the barometer, &c. appears, notwithstanding, to have passed hitherto without due attention.

Of the cirro-cumulus.

The cirrus having continued for some time increasing, or stationary, usually passes either to the cirro-cumulus, or the cirro-stratus; at the same time descending to a lower station in the atmosphere.

The cirro-cumulus is formed from a cirrus, or from a number of small separate cirri, by the fibres collapsing, as it were, and passing into small roundish masses, in which the texture of the cirrus is no longer discernible, although they still retain somewhat of the same relative arrangement. This change takes place, either throughout the whole mass at once, or progressively from one extremity to the other. In either case, the same effect is produced on a number of adjacent cirri at the same time, and in the same order. It appears in some instances to be accelerated by the approach of other clouds; and is probably due to the equilibrium of the electric fluid between the cloud and the surrounding atmosphere.

This modification forms a very beautiful sky, sometimes exhibiting numerous distinct beds of these small connected clouds floating at different altitudes.

The cirro-cumulus is frequent in summer, and is attendant on warm and dry weather. It is also occasionally, and more sparingly, seen in the intervals of showers, and in winter. This cloud is a sure prognostic of increased temperature. It may either evaporate, or pass to the cirrus or cirro-stratus.

Of the cirro-stratus.

This cloud appears to result from the subsidence of the fibres of the cirrus to a horizontal position, at the same time that they approach towards each other laterally. The form and relative position, when seen in the distance, frequently give the idea of shoals of fish. Yet in this, as in other instances, the structure must be attended to, rather than the form, which varies much; presenting at other times the appearance of parallel bars, interwoven streaks like the grain of polished wood, &c. It is always

thickest in the middle, or at one extremity, and extenuated towards the edge. The distinct appearance of a cirrus does not always precede the production of this and the last modifications.

The cirro-stratus precedes wind and rain, the near or distant approach of which may sometimes be estimated from its greater or less abundance and permanence. It is almost always to be seen in the intervals of storms. Sometimes this and the cirro-cumulus appear together in the sky, and even alternate with each other in the same cloud, when the different evolutions which ensue are a curious spectacle; and a judgment may be formed of the weather likely to ensue, by observing which modification prevails at last. The cirro-stratus is the modification which most frequently and completely exhibits the phenomena of the solar and lunar halo, and (as supposed from a few observations) the parhelion and paraselene also. Hence the reason of the prognostic for foul weather commonly drawn from the appearance of halo. This cloud is among those natural indications which may be trusted in confirmation of the indications of the barometer and hydrometer for rain. It may be reasonably thought to originate from a supervening cold and moist current, occasioning precipitation in the atmosphere below, before it is itself to be perceived. Its appearance often indicates the simple act of subsidence, as in common cases of precipitation in fluids at rest.

Of the cumulo-stratus.

The different modifications which have been just treated of, sometimes give place to each other: at other times two or more appear in the same sky; but in this case the clouds in the same modification lie mostly in the same plane of elevation, those which are more elevated appearing through the intervals of the lower, or the latter showing dark against the lighter ones above them. When the cumulus increases rapidly, a cirro-stratus is frequently seen to form around its summit, reposing thereon as on a mountain; while the former cloud continues discernible in some degree through it. This state continues but a short time. The cirro-stratus speedily becomes denser, and spreads; while the superior part of the cumulus extends itself, and passes into it, the base continuing as before, and the convex protuberances changing their position till they present themselves laterally and downward. More rarely the cumulus alone performs this evolution, by the movement or mode of increase of its superior part.

In either case, a large lofty dense cloud is formed, which may be compared to a mushroom with a very thick short stem. But when a whole sky is crowded with this modification, the appearances are more indistinct. The cumulus rises through the interstices of the superior clouds; and the whole, seen as it passes off in the distant horizon, pres nts to the fancy mountains covered with snow, intersected with dark ridges and lakes of water, rocks and towers, &c. the distinct cumulo-stratus is formed in the interval between the first appearance of the fleecy cumulus and the commencement of rain; also during the approach of thunder-storms. The indistinct appearance of it is chiefly in the longer or shorter interval of showers of rain, snow, or hail.

The cumulo-stratus chiefly affects a mean state of the atmosphere, as to pressure and temperature, but is not peculiar to any season; and it may be seen before a fall of snow, as well as before a thunder-storm.

Of the nimbus, or cumulo-cirro-stratus.

Clouds in any one of the preceding modifications, at the same degree of elevation, or two or more of them, at different elevations, may increase so as completely to obscure the sky, and at times put on an appearance of density, which to the inexperienced observer indicates the speedy commencement of rain. It is nevertheless extremely probable, as well from attentive observation, as from a consideration of the several modes of their production, that the clouds, while in any one of these states, do not at any time let fall rain.

Before this effect takes place, they have been uniformly found to undergo a change, attended with appearances sufficiently remarkable to constitute a distinct modification. These appearances, when the rain happens over our heads, are but imperfectly seen. We can then only observe, before the arrival of the denser and lower clouds, or through their interstices, that there exists at a greater altitude a thin light veil, or at least a hazy turbidness. When this has considerably increased, we see the lower clouds spread themselves till they unite in all points, and form one uniform sheet. The rain then commences; and the lower clouds, arriving from the windward, move under this sheet, and are successively lost in it. When the latter cease to arrive, or when the sheet breaks, every one's experience teaches him to expect an abatement or cessation of rain. But there often follows, what seems hitherto to have been unnoticed, an immediate and great addition to the quantity of cloud. For on the cessation of rain, the lower broken clouds which remain rise into cumuli, and the superior sheet puts on the various forms of the cirro-stratus, sometimes passing to the cirro-cumulus.

If the interval is long before the next shower, the cumulo-stratus usually makes its appearance, which it also does sometimes very suddenly after the first cessation.

But we see the nature of this process more perfectly, in viewing a distant shower in profile.

If the cumulus be the only cloud present at such a time, we may observe its superior part to become tufted with cirri. Several adjacent clouds also approach, and unite laterally by subsidence.

The cirri increase, extending themselves upward and laterally; after which the shower is seen to commence. At other times the converse takes place of what has been described relative to the cessation of rain. The cirro-stratus is previously formed above the cumulus; and their sudden union is attended with the production of cirri and rain.

In either case the cirri vegetate, as it were, in proportion to the quantity of rain falling; and give the cloud a character by which it is easily known at great distances, and to which, in the language of meteorology, we may appropriate the *nimbus* of the Latins:

> Qualis ubi ad terras abrupto sidere nimbus
> It mare per medium; miseris, heu! prescia longe
> Horrescunt corda agricolis.—Virgil.

When one of these arrives hastily with the wind, it

brings but little rain, and frequently some hail or driven snow. In heavy showers the central sheet, once formed, increases to windward, the cirri being propagated above and against the lower current, while the cumuli, arriving with the latter, are successively arrested in their course, and contribute to reinforce the shower.

In continued gentle rains it does not appear necessary, for the resolution of clouds, that the different modifications should come into actual contact. It is sufficient, that there exist two strata of clouds, one passing beneath the other, and each continually tending to horizontal uniform diffusion. It will rain during this state of the two strata, although they should be separated by an interval of many hundred feet in elevation.

As the masses of cloud are always blended, and their arrangement destroyed, before rain comes on, so the reappearance of those is the signal for its cessation. The thin sheets of cloud which pass over during a wet day, certainly receive from the humid atmosphere a supply proportionate to their consumption; while the latter prevents their increase in bulk. Hence a seeming paradox, which yet accords strictly with observation; that for any given hour of a wet day, or any given day of a wet season, the more cloud the less rain. Hence also arise some further reflections on the purpose answered by clouds in the economy of nature. Since rain may be produced by, and continue to fall from, the slightest obscuration of the sky, by the nimbus, that is, by two sheets in different states, while the cumulus, or cumulo-stratus, with the most dark and threatening aspect, passes over without letting fall a drop, until their change of state commences; it should seem that the latter are the reservoirs, in which the water is collected from a large space of atmosphere, for occasional and local irrigation in dry seasons, and by means of which it is also arrested at times in its descent, in the midst of wet-ones. In this so evident provision for the sustenance of all animal and vegetable life, as well as for the success of mankind in that pursuit so essential to their welfare, in temperate climates, of cultivating the earth, we may discover the wisdom and goodness of the Creator and Preserver of all things.

The nimbus, although in itself one of the least beautiful clouds, is yet now and then superbly decorated with its attendant, the rainbow, which can only be seen in perfection when backed by the widely extended uniform gloom of this modification.

METHOD in logic, &c. the arrangement of our ideas in such a regular order, that their mutual connection and dependance may be readily comprehended.

METONYMY, in rhetoric, is a trope in which one name is put for another, on account of the near relation there is between them. By this trope any of the most significant circumstances of a thing are put for the thing itself. See RHETORIC.

METOPE. See ARCHITECTURE.

METRE, in poetry. See HEXAMETER, PENTAMETER, &c.

METROSIDEROS, a genus of the class and order icosandria monogynia. The Calyx is five-cleft, half-superior; petals five; stamina very long, standing out; stigma simple; capsule three-celled. There are 13 species, of New Holland, &c.

MEZEREON. See DAPHNE.

MEZZOTINTO. See ENGRAVING.

MIASMA, among physicians, denotes the contagious effluvia of pestilential diseases, whereby they are communicated to people at a distance.

MICA. This stone forms an essential part of many mountains, and has been long known under the names of glacies Mariæ, and Muscovy glass. It consists of a great number of thin laminæ adhering to each other, sometimes of a very large size. Specimens have been found in Siberia nearly $2\frac{1}{2}$ yards square.

It is sometimes crystallized; its primitive form is a rectangular prism, whose bases are rhombs with angles of 120° and 60°: its integrant molecule has the same form. Sometimes it occurs in rectangular prisms. whose bases also are rectangles, and sometimes also in short six-sided prisms; but it is much more frequent in plates or scales of no determinate figure or size.

Its texture is foliated. Its fragments flat. The lamellæ flexible, and somewhat elastic. Very tough. Often absorbs water. Specific gravity from 2.6546 to 2.9342. Feels smooth but not greasy. Powder feels greasy. Colour, when purest, silver white or grey; but it occurs also yellow, greenish, reddish, brown, and black. Mica is fusible by the blowpipe into a white, grey, green, or black enamel; and this last is attracted by the magnet. Spanish wax rubbed by it becomes negatively electric.

A specimen of mica, analysed by Vauquelin, contained

50.00	silica
35.00	alumina
7.00	oxide of iron
1.35	magnesia
1.33	lime.
94.68	

Mica has long been employed as a substitute for glass. A great quantity of it is said to be used in the Russian marine for panes to the cabin-widows of ships; it is preferred, because it is not so liable as glass to be broken by the agitation of the ship. It is also used in our navy for lantherns, for the use of the powder-rooms.

MICHELIA, a genus of the octandria polygynia class of plants, the flower of which consists of eight petals; the fruit consists of a number of globose unilocular berries disposed in a cluster; in each of which there are four seeds, convex on one side, and angular on the other. There are two species, trees of the East Indies.

MICHAUXIA, a genus of the class and order octandria monogynia. The calyx is 16-parted; corolla wheel-shaped, 8-parted; nect. 8-valved, staminiferous; caps. 8-celled, many-seeded. There is one species, a biennial of Aleppo, resembling the campanula.

MICROMETER, an astronomical machine, which, by means of a screw serves to measure extremely small distances in the heavens, &c. and that to a great degree of accuracy.

The micrometer consists of a graduated circle (Plate XCIV. Miscel. fig. 162), of a screw *qo*, and its index *qr*. The threads of the screw are such, that 50 make the length of one inch exactly. When it is to be used, the point *o* is set to the side of the part to be measured, and then the index is turned about with the finger, till the eye perceives the point has just passed over the diameter of that part; then

the number of turns, and parts of a turn, shown by the graduated circle, will give the dimensions in parts of an inch, as we shall show by the following example: Suppose it is required to measure the diameter of a human hair, and I observe the index is turned just once round while the point *o* passes over it; then it is plain the diameter of the hair in the image is $\frac{1}{50}$th of an inch. Now if the microscope, I D E F, *d e f*, magnifies 6 times, or makes the image 6 times larger in diameter than the object, then is the diameter of the hair itself but $\frac{1}{6}$th of $\frac{1}{50}$, that is, but $\frac{1}{300}$th, part of an inch.

Also it is to be observed, that as there are ten large divisions, and twenty small ones, on the micrometer plate, so each of those small divisions is the $\frac{1}{20}$th of $\frac{1}{50}$th, or the $\frac{1}{1000}$th part of an inch. Therefore, if, in measuring any part of an object, you observe how many of these smaller divisions are passed over by the index, you will have so many thousandth parts of an inch for the measure required.

There have been micrometers contrived by various persons. We shall describe one invented by Mr. Cavallo, which consists of a small semitransparent scale or slip of mother-of-pearl, about the 20th part of an inch broad, and of the thickness of common writing paper. It is divided into a number of equal parts by means of parallel lines. This micrometer is situated within the tube, at the focus of the eye-lens of the telescope, where the image of the object is formed, and with its divided edge passing through the centre of the field of view. It is to be fixed upon the diaphragm, which generally stands within the tube at the focal distance of the eye-lens.

By looking through the telescope, the image of the object and the micrometer will appear to coincide; hence the observer may easily see how many divisions of the latter measure the length or breadth of the former; and knowing the value of the divisions of the micrometer, he may easily determine the angle which is subtended by the object.

To ascertain the true value of the divisions of a micrometer in a telescope—Direct the telescope to the sun, and observe how many divisions of the micrometer measure its diameter exactly; then take from the nautical almanac the diameter of the sun for the day on which the observation is made; divide it by the number of divisions, and the quotient is the value of one division of the micrometer. Ex. Suppose that $26\frac{1}{2}$ divisions of the micrometer measure the diameter of the sun, and the angle of the sun is $31' 22''$, or $1832''$, which divide by 26.5, and the quotient is $71''$ or $1' 11''$; this is the value of one division of the micrometer; the double of which is the value of two divisions; the treble is the value of three divisions, and so on. See Phil. Trans. Vol. 81.

MICROPUS, *bastard cudweed*; a genus of the polygamia necessaria order, in the syngenesia class of plants; and in the natural method ranking under the 49th order, compositæ. The receptacle is paleaceous; there is no pappus; the calyx is caliculated; there is no radius of the corolla. The female florets are wrapped in the scales of the calyx. There are two species, the supinus and erectus; but only the former is ever cultivated in gardens. It is an annual plant, growing naturally in Portugal; and is frequently preserved in gardens on account of the beauty of its silvery leaves. It is easily propagated by seed sown in autumn, and requires no other culture than to be kept free from weeds.

MICROSCOPE. See Optics.

MICROTEA, a genus of the pentandria digynia class and order. The calyx is five-leaved, spreading; corolla, none; drupe, dry, echinated. There is one species, an annual of the West Indies.

MIDWIFERY, in the restricted sense of the word, is the art of assisting women in childbirth. It is generally, however, made to comprehend the management of women, both previously to, and some time after, delivery; as well as the treatment of the infant in its early state.

It is usual to commence dissertations on this art, with the anatomy and physiology of the female organs of generation: for the former of these, the reader is referred to the article Anatomy; and the physiology of the generative functions, with the subject of conception, will be found treated of under the head of Physiology.

We shall, in the present article, commence by tracing the progressive changes which take place in the uterine system, consequent upon, and immediately after, impregnation; we shall then notice, in a general manner, the subject of spurious pregnancy, with that of superfœtation; treat of the morbid affections which, under some circumstances of predisposition, uterine gestation induces; give an account of the three kinds of labours, natural, difficult, and preternatural; and conclude with describing the requisite treatment of the female after delivery.

Of the changes which impregnation induces in the uterine system.—The ovum is constituted in early uterine gestation, by the embryo or unformed fœtus, the umbilical chord or navel string, the membranes, and the waters. It at first appears as an unformed mass, the component parts not being capable of separation, or even distinction. Soon after conception, the external lamella grows thinner, the rudiments of the fœtus become more apparent, and at length a thick vascular substance (the placenta) is developed, distinct from the membranous portion of the ovum.

This membranous portion is formed originally of two coats; that next the fœtus is named amnion; and the external, the true chorion. These are decidedly organized membranes; but beyond these there is an external lamella, which is at first loosely spread over the ovum, but afterwards comes into actual contact with the true chorion. This external lamella is much thicker than the other membranes, and in early conception composes a very large part of the ovum; it was denominated by Ruysch, tunica filamentosa, it has been since termed, the false or spongy choroin; more recently, however, two layers have been detected in it, one covering the ovum, and the other lining the uterus. This last, Dr. Hunter has called membrana decidua, on account of its being cast off after delivery; while to that portion which immediately covers the ovum, he has given the name of decidua reflexa, because it is reflected from the womb upon the ovum, and forms the connecting medium between them.

Thus the ovum, on its first formation, and afterwards, when it receives the appellation of fœtus, is enveloped by four membranes; the decidua, the decidua reflexa (these two eventually come to be blended), the true chorion, and the amnion.

We have already said, that the chorion and the amnion

are decidedly organized, and composed of fibrous layers: the decidua has been generally supposed to be formed of extravasated blood, or coagulable lymph; it has recently, however, been argued, and we think justly, that the decidual is likewise a truly organized membrane.

Dr. Denman calls the decidua, the connecting membrane of the ovum: its formation is contemporary with conception, and precedes the time at which we have commenced our description; viz. when the ovum has passed from the ovarium into the uterus: as a proof of this uterine and prior formation of the decidual membrane, we may mention that it is found in the case of an extra-uterine fœtus.

Between the chorion and the amnion, we find in the early months of pregnancy, a quantity of gelatinous fluid, and near the insertion of the umbilical chord, a small white speck is seen on the latter membrane, which is a sac filled with a white milky kind of liquor; it is called the vesicula lactea or umbilicalis; this communicates with the navel-string by a small chord, which, however, with the sac to which it leads, are only observable in the early months of gestation; their use has not been ascertained.

In the first instance, the involucra of the embryo constitute by far the largest part of the ovum; the proportions afterwards come to be reversed: an ovum, for example, at the end of eight weeks, is about the size of a hen's egg, while the embryo itself weighs very little more than a scruple; in eight months from conception, the fœtus, on the contrary, weighs somewhat more than five pounds, while the secundines do not much exceed one pound.

Contents of the uterus in advanced pregnancy.—In advanced pregnancy, the contents of the gravid uterus are the fœtus, with the navel-string, the placenta, membranes, and contained fluid.

The placenta is the medium of communication between the fœtal and maternal part of the gravid uterus; this is a thick vascular mass, attached to the fœtus by the navel string or chord, and to the womb by means of the spongy chorion or decidua; the chord invariably proceeds from the navel of the fœtus, but its attachment to the placenta is not always in the same place; it is composed of two arteries, and a vein enveloped with tunics, and distended with a quantity of gelatinous viscid substance. The umbilical chord is without nerves, as then there is no sentient communication between the fœtus and the mother: the nævi materni, or marks as they are called, on children, cannot originate from the causes to which they are vulgarly attributed; longings, &c. on the part of the parent.

It is about the fifth month that the connection, of which we have already spoken, is formed between the two layers of the decidua, or between the membrana decidua and the decidua reflexa; the double decidua thus formed, is, in comparison with the other membranes, opaque.

The true chorion is the firmest, smoothest, and most transparent, of all the fœtal involucra, with the exception of the amnion; with this last it is united, through the intervention of a gelatinous substance. The amnion is the thinnest and most transparent of the membranes, and, in the human subject: no vessels have hitherto been traced in this membrane; while, however, it is thinner, it is stronger, than the chorion, and when the membranes are about to break, gives the greatest resistance.

In addition to these coverings, we find in the quadruped an oblong membranous sac or pouch (the allantois) situated between the chorion and the amnion; this membrane communicates with the urachus, which in brutes is open, and transmits the urine hither from the bladder (See Comparitive Anatomy.) Now that small sac which we have described, as placed in the earlier months of gestation between the chorion and amnion, has been thought by some anatomists to be the urachus; in the human subject, however, there is no allantois, and no communication of this kind.

The waters of the gravid uterus are enclosed within the amnion, and are called liquor amnii; in the first months, they are purer and clearer than in more advanced pregnancy, at which time they become more opaque and gelatinous. After a certain period, the waters diminish proportionally to the advance of impregnation; they are composed of a saline fluid, and appear to be altogether excrementitious.

Sometimes water is collected between the lamellæ of the chorion, or between the chorion and amnion; this constitutes the false water: it is generally in much smaller quantity than the true water, and may be discharged at any period of pregnancy without injury.

Progressive increase of the uterine organs.—The uterus, although gradually augmenting in capacity from the first moment of conception, is never completely distended; in early gestation, its contents are confined to the fundus; and even when the fœtus has arrived at its full growth, the finger may be introduced some way within the uterine orifice, without interfering with the membranes. The increasing size of the uterus does not depend upon the parts being mechanically stretched, but upon a gradual evolution in the manner of organic growth, in general.

It is not easy to determine on pregnancy, from the appearances in the early months; during the three first months succeeding to conception, the os tincæ feels smooth, and its orifice does not undergo any sensible enlargement; between the third and fifth month, a dilatation commences in the cervix and orifice; the latter begins to assume a different appearance and to project more into the vaginal cavity.

More decisive marks of the existence and period of pregnancy are furnished by the progressive augmentation of the abdominal tumour. Between the fourth and fifth month, the fundus uteri begins to rise above the brim of the pelvis, and its cervix comes now to be distended. In the fifth month, the abdomen enlarges considerably, the fundus uteri extends about midway, between the pubis and the umbilicus, and its cervix is sensibly shortened. In the seventh month, the fundus reaches the navel, and the cervix is now distended nearly three-fourths. In the eighth, it has advanced about half-way between the umbilicus and scrobiculus cordis; and in the ninth, it has reached the scrobiculus; the cervix uteri is now completely distended. The womb, then, in the last period of pregnancy, occupies all the umbilical and hypogastric regions: its shape is nearly pyriform.

During the progress of pregnancy, the substance of

is retained, if this membrane is not discharged; if the blood evacuated is pure and free from clots, and is unattended with pain or the feeling of pressure, abortion from hæmorrhage is less to be apprehended.

The causes disposing to abortion, are much weakness and irritability of the frame; the more immediately exciting causes are, violent passions of the mind, excessive bodily agitation, or mechanical injuries. The position or motion of the fœtus itself may likewise dispose to miscarriage.

The size of the abortive ovum, about six weeks succeeding to conception, is nearly about that of a pigeon's egg; in two months its bulk is that of a common hen's egg, and in three months it equals the size of a goose's egg.

Where we have reason to apprehend abortion, every attention is to be given to avoid the exciting causes. On the first appearance of menacing symptoms, the patient should be principally confined to a horizontal position, the diet should be nourishing but not irritating; the mind should be kept as free as possible from agitation; and crowded irregularly heated apartments shunned.

When the hæmorrhage has come on, and the abortion followed, vegetable astringents are to be given, with opiates and bark; the bowels are at the same time to be kept evacuated, and in cases of great debility, port wine is to be copiously taken; sometimes cold or astringent applications to the vagina are necessary. (See Menorrhagia, in the article Medicine.)

Natural labours.—That increase of the uterus, by which it adapts itself to the increasing size of its contents, in pregnancy, has certain limits. In the course of thirty-nine weeks from conception, it refuses to undergo any further enlargement, hence contraction ensues, by which those sensations are excited which constitute labour-pains. These, at first, are comparatively trivial, and only recur after a considerable interval; afterwards, however, they become more frequent and forcible; till at length, from the power of uterine contraction, aided by the action of the diaphragm and abdominal muscles, the membranes are ruptured, the os uteri dilated, and the child born.

Approaching labour is indicated by the subsiding of the abdominal tumour; hence a relief from the sensations of weight and pressure; an excretion of mucus from the vagina, which is sometimes tinged with blood, succeeds, attended with difficulty of discharging, or total suppression of, urine; tenesmus, abdominal pains, which extend to the loins and pubes; much restlessness, alternate rigours and flushes of heat.

What are termed spurious labour-pains, are more irregular than those of genuine labours; they do not produce any alteration in the orifice of the womb, and are not attended with any considerable discharge of mucus, by which genuine labour is sometimes preceded, and always accompanied.

The prognosis of labour cannot, with precision, be formed. The more ordinary limits of a natural easy labour, from its actual commencement, is, from six to twelve hours: sometimes, however, it is completed at the end of two hours, and at others is protracted for some days. The first labour is almost invariably the most tardy as well as the most painful.

In natural parturition, the accoucheur has no occasion for interference until the membranes are ruptured; to this succeeds the dilatation of the os uteri, and the head of the child is forced against the perinæum; the accoucheur is now required, during every pain, gently to press with the palm of his hand against the perinæal tumour, formed by the head of the child; the perinæum itself is likewise to be lubricated. The head will be expelled through the orificium externum, in consequence of the resistance given by the perinæum, which must be released by cautiously passing it over the face and chin of the child; and now the female is to be suffered to rest for a minute or two, until the recurrence of a fresh labour-pain, by which the body of the child will be protruded, and the delivery effected.

The child is to be removed as far as the umbilical chord will permit; which, when the infant has shown signs of life, must be tied and cut; the child is then to be wrapped in a warm receiver, washed, and dressed. See Infancy.

The parts of the female are to be very gently wiped, a warm soft cloth applied, and the delivery of the placenta or afterbirth waited for. The approach of its expulsion is usually announced by the discharge of some clotted blood, and by what are termed griping pains; its advancing is ascertained by the shifting of the abdominal tumour, and by the lengthening of the chord, which should be twisted round the finger of the right hand, while two fingers and thumb of the left hand are made to grasp that part of it within the vagina; and when a pain presents, it will in this manner be extracted without employing force; if any difficulty arises from the passage of the bulky part of the placenta through the vagina, the finger and thumb of the right hand may be passed up the chord, and the edges gently loosened.

But should the placenta not advance when the chord is completely extended, and the female suffer pain, the operator must desist. A soft warm cloth should be applied to the uterine orifice, and the patient allowed to rest for some minutes; and in the mean time, a gradual pressure may be made on the abdomen, to assist the uterine contraction, and facilitate the extraction of the placenta, which, in by far the majority of cases, is disengaged and expelled within less than an hour after the birth of the child. From want of power, however, in the uterus, from spasmodic action of this organ, or from a diseased state of the placenta itself, it may be retained in the uterus, and give rise to unpleasant symptoms.

When it becomes necessary to employ force in the extraction, which is perhaps never the case but in instances of flooding, the female should be laid on her back; the accoucheur must pass his hand well lubricated into the uterus, and search for the convex body of the afterbirth, the adhesions of which must be gradually separated by the fingers; and when the whole body is loosened it must be carefully brought away.

Much controversy has recently arisen with respect to the eligibility of a forcible extraction of the placenta; it cannot be denied, that a retension of this substance has been attended with fatal consequences; while, on the other hand, precipitate and too forcible efforts to procure its extraction, have been followed by fatal accidents. Perhaps it may be laid down as a general rule, that although the expulsion of the placenta is earnestly to be wished, its retention is attended with much less risk than

a forcible extraction, when the vital power is insufficient to endure much manual force.

Difficult labour.—Either from a diminution of the uterine propelling powers, or an increase of the resisting ones, delivery may be protracted beyond the ordinary period, although the head of the child presents in its natural course. When this happens, the labour may be denominated difficult; difficult labours may be referred to the condition of the mother, the child, or the secundines.

Thus, in the first place, they may be occasioned or attended by uterine hæmorrhage, epileptic fits, spasms, faintings, nausea, hectic or consumptive state, mental agitations, and mismanagement in the time of labour: or the impediment to the progress of labour may be local, as from narrowness of the pelvis or other distortions, constriction and dryness of the vagina, rigidity of the os tincæ, schirri or polypi in the uterus or vicinity, accumulated fæces, calculus, prolapsus of the uterus, vagina and rectum, obliquity of the womb.

In the second place, the impediment may be occasioned by the bulk and ossification of the child's head, the manner in which it presents, and the largeness or transverse presentation of the shoulders.

Thirdly, in the secundines there may be too great a rigidity of the membranes, or the contrary; too large a quantity of water; the navel-chord may be too long or too short, or it may prolapse before the child's head; and lastly, the placenta may be attached towards the cervix or mouth of the womb. On each of these causes and their remedies, we shall now proceed to descant.

When hæmorrhage or flooding occurs with genuine labour pains, the membranes are to be broken, as soon as the dilatation of the mouth of the womb is sufficient to admit the hand; the hæmorrhage, upon the discharge of the water, will generally abate; in this case, the patient must be carefully preserved from being heated, opiates must be administered and the natural process of delivery awaited.

If the hæmorrhage, as has happened in some few cases, depends upon a separation of the placenta, attached towards the neck of the womb, the flow of blood may be impetuous, from the separation of the cake, before the uterus is sufficiently dilated to admit the passage of the child's head. In this case the membranes are to be broken, and the delivery effected by turning or extracting with the forceps or crochet, with as much expedition as is consistent with the safety of the mother. Upon the occurrence of epileptic fits, cramps in the thighs, legs, &c. faintings, and other symptoms, which are consequences as well as causes of protracted labour, no general rules can be given. The excitement or strength should be supported in these cases of nervous irritability, heat and fatigue must be sedulously guarded against, opiates given, and the progress of the labour waited for. In cases, however, of violent epileptic attacks, the delivery of the child should be effected as soon as possible.

When a febrile disposition is more than usually conspicuous, the bowels must be kept gently open, and a cooling regimen adopted.

In cases of severe colic presenting immediately before the pains of labour, emollient clysters should be injected, followed by opium.

Nausea and sickness must be combated by diluent liquids, by bitters, and by small doses of opium.

When labours occur in the consumptive state, they are almost invaribly lingering. Under these circumstances, that posture of the body should carefully be chosen for the female, in which respiration is best promoted; the head and breast should be elevated more than in ordinary cases; and the apartment preserved cool and airy, but free from currents of air. After delivery, in instances of confirmed phthisis, the symptoms, which during pregnancy had been in some measure mitigated and suspended, recur with an alarming and fatal rapidity.

It scarcely requires to be observed, that all sources of mental agitation, even those which without scruple would be admitted at other times, should be sedulously prevented in incipient labour; violent flooding, convulsion, and fatal deliquia, have been induced at this period from deficient observance of such caution.

The above-mentioned obstructions to the progress of labour are of a general nature; impediments, however, to delivery may depend upon local causes: the first of these we have mentioned, are, narrowness and distortions of the pelvis, or other bones. In all cases indeed of deformity, such as curved spine, bowed legs, much projection of the breast-bone, &c. the labour may be difficult, independantly of actual deformity of the pelvis; but the former are likewise frequently combined with the latter. The pelvis may be faulty at its upper and inferior portion, or in its cavity.

In the first case, we can only ascertain the distortion from the symptoms in pregnancy; the pelvis is known to be too small, or the head of the child disproportionally large, by the latter not advancing in proportion to the pains; and by feeling a sharp ridge on the top of the child's head occasioned by the bones riding over each other in consequence of pressure.

If the patient's strength rapidly falls, if the child's head begins to swell, and the parts of the female to tumify and inflame, the artificial mode of delivery must now be resorted to, taking great care not to be too precipitate in the application either of instruments or of force.

Local obstructions may exist also in the soft parts; the vagina may be dry and constricted; in which case all stretching and mechanical force is to be avoided, and the parts lubricated by oily substances or warm applications. When a thickness and rigidity of the os tincæ obstruct labour, as in women advanced in life, the parts may likewise be lubricated, and here opiates are often necessary. In this case no forcible attempts should be made to open the uterus. Polypous or other tumours sometimes, but very rarely, require extirpation, in order to facilitate the passage of the child through the vagina. When difficulty occurs from accumulated fæces, emollient clysters must be had immediate recourse to. Calculi, if they obstruct the passages, must, when they cannot be pushed back, be cut open and extracted.

When prolapsus of the uterus occurs from the too great capacity of the pelvis, the womb must be supported in time of pain that the stretching of parts may be gradual. When the vagina or rectum prolapse, they must be reduced by gentle pressure during the intervals of the pains, and a return obviated by very gentle pressure.

Obliquity of the womb never, perhaps, interferes with the progress of labour, except in cases of a pendulous abdomen or distorted pelvis.

Labour may be protracted from peculiarities in either the form or position of the child's head.

Natural disproportion in size may take place in the head of the infant; it may be enlarged from emphysema, in consequence of the death of the fœtus, or this enlargement may originate from hydrocephalus: the first of these can only be detected by the tardy advances of the child, when compared with the violence of the labour-pains; the second is discovered from previous symptoms, and from the emphysematous feel of the presenting head; the last may sometimes be ascertained by a separation of the bones, and a fluctuation in the head.

In these cases recourse must be had to instruments; and if by any force properly employed the head cannot be made to pass, the cranium must be pierced and the brain extracted, previous to the delivery.

The mere unfavourable position of the head may be referred to two kinds. 1st. Where the open of the head, or fontanella, presents instead of the vertex; and 2dly, face-cases.

If the former is the obstacle, the labour will generally terminate well without artificial aid. Face-cases, however, are often extremely difficult and laborious: their varieties are constituted by the direction of the chin to the pubes, or to the sacrum, or to either side. In these cases the labour must be permitted to proceed, till the face is protruded as far down as possible. It is often as hazardous and as difficult to thrust back the child, and bring down the vertex, as to turn it and deliver by the feet. Sometimes the attempt to alter the position may succeed; or where the face is considerably advanced, the fingers may be placed in the mouth of the child, and the jaw pulled down, by which the bulk of the head will be diminished; or the chin may be pressed to bring it under the arch of the pubes, by which the crown will be pushed into the hollow of the sacrum, and the passage of the head thus facilitated.

Labour is seldom obstructed by the breadth of the shoulders; if the shoulders do not pass after several pains, the accoucheur may assist the delivery by passing a finger on each side as far as the axilla.

Lastly, the difficulty and danger of labour may have reference to the secundines.

From the rigidity of the membranes the birth is not so frequently rendered tedious as from the opposite cause; and as many inconveniences arise from the premature evacuation of the waters, this accident should be guarded against rather than encouraged.

The impediment to delivery from too great a quantity of water seldom proves dangerous; even here the membranes should never be broken till the soft parts are fully dilated.

When the navel-string is too long, the labour may be protracted from its circumvolutions passing round the child's neck or body. This, however, is very seldom the case, and it is almost never necessary or proper to divide the chord in the birth; a practice that may be attended with fatal consequences.

When the funis is too short, a precipitate expulsion of the placenta may be the consequence, or the rupture of the chord and death of the child; this case, however, very rarely happens. When the funis is prolapsed before the head, it should, if possible, be thrust up above the presenting part; for the circulation of the chord, and consequent death of the child, may otherwise take place. If the head is far advanced, and the life of the child in danger, delivery may be performed with the forceps.

When the placenta is attached towards the neck or orifice of the uterus, the danger from hæmorrhage is very considerable, and the delivery is to be accomplished as speedily as possible.

By the above observationi it will be rendered evident, that the practice of manual or instrumental assistance, even in difficult labour, is very seldom requisite; as, however, there are cases where the defects of nature may be in some measure remedied by art, it will be proper more particularly to speak

Of the mode of delivery by instruments.

Forceps. This is an instrument which in its improved form may be used without endangering the safety of either mother or child. When it is requisite to employ it with the head presenting naturally, the female must be laid on her back across the bed, and the accoucheur kneeling before her is first to lubricate the perinæum and the vagina, then gently dilate the parts by passing his hand through the vagina by the side of the child's head till it advances as far as an ear; along the hand he is to guide a blade of the forceps, which is to be introduced in the direction of the line of the pelvis, the handle held backwards towards the perinæum, and the clam kept closely applied to the child's head. This must be insinuated by degrees with a kind of wriggling motion, till the blade is applied along the side of the head over the ear: the operator must then withdraw the first hand from the pelvis, and secure the handle of the blade already introduced, till the other blade is insinuated in the same manner; the handles must then be brought exactly to antagonize each other, and then the blades are to be locked. Now, while one hand is engaged in defending the perinæum, the other must be employed in moving the forceps from blade to blade, not straight forwards; and the accoucheur should only operate during the pains, if any, and if not he should frequently desist.

When the perinæum begins to protrude, the operator must rise, elevate the handle of his instrument very gently, and by a turn bring the head round from under the arch of the pubes, carefully preserving the perinæum from being lacerated.

When the vertex presents with the face laterally in the pelvis, the instrument must not be introduced till the ear of the child has passed under the pubes; the woman should now be placed on her side or knees, and when the forceps are passed, should again be placed on her back, and the head be delivered in the manner it presents. When the forceps in this case fails, it must be fixed over the head and occiput; if this last method does not succeed, the size of the head must be diminished.

If the fontanella presents with the face to the pubes or sacrum, the forceps may be applied in the same manner as in a natural presentation; here the extraction should be made with extreme deliberation, the forceps must be released when the head is delivered, and the remainder of the delivery regulated as under ordinary circumstances.

In this case of fontanel presentation, the short diameter of the pelvis is intersected by the long axis of the head, and it is thus rendered impossible to bring the head along by any force we are justified in using. In this case, the common forceps being withdrawn, the long one is to be had recourse to. An instrument has likewise been employed in these cases with a third blade.

In face-presentations, the accoucheur is to pass his hand with great gentleness within the pelvis, and only during the intervals of pain endeavour to push the shoulders above the brim of the pelvis; should this succeed, the labour will perhaps proceed orderly; if, however, every endeavour is baffled to make the crown or fontanel present, the forceps is to be applied over the ears of the child, and the extraction performed in the best manner the accoucheur is able: if this fails, recourse must be had to the crotchet. When the face presents with the chin to the pubes, previous to the introduction of the forceps, the chin, if possible, should be brought down below the pubes. When the chin is to the sacrum, it should be advanced to its inferior part; and when it is laterally directed, the chin should be as low as the under part of the tuber ischii before the instrument is employed.

Embryotomy. When every method has failed of extracting the head of the child, this operation must be had recourse to; that is, the skull must be perforated, and its contents evacuated. This is a modern and important improvement in the art of midwifery: the instruments by which the operation is to be accomplished, consists of a pair of long scissars, a sharp curved crochet, and a blunt hook. It is unnecessary to say, that embryotomy should never be employed but in cases of absolute necessity; and where the demonstration is complete, that the dimensions of the pelvis are insufficient to admit the passing of the child's head.

In the narrowest pelvis that presents, the soft parts should be fully dilated previous to perforating the cranium; the head of the child is to be fixed firmly in the pelvis, and advanced as far as possible; the long scissars are to be introduced into the vagina by the direction of the hand, and the points guarded till they apply to the cranium of the child, which they must be made to perforate till they are inserted as far as the rests; they are then to be fully dilated, carefully closed again, half-turned, and again dilated, so as to form a crucial hole in the scull. Now, they are to be thrust beyond the rests, opened and shut for several times, till a very large opening is made; the scissars are then to be withdrawn carefully, and the brain extracted by means of the fingers or blunt hook, and if any portion of bone is found loose it is to be removed by the fingers or small forceps. The teguments of the scalp should now be drawn over the cranial perforation, and the extraction delayed for some hours; sometimes the force of natural labour-pains will suffice for the expulsion of the head; if not, it must be drawn forward by means of two fingers introduced into the cavity of the cranium, by the blunt hook, or by the crotchet; which last is to be introduced in the same manner as a blade of the forceps, taking care to guard the point with the finger; the force employed must be exerted by intervals, and if there are labour-pains, only during their occurrence; sometimes it is necessary to employ considerable exertion in order to effect the extraction: if, after the head has passed, the body resists the extracting power, the thorax must be pierced, and some of its contents likewise discharged.

If, from great inattention or ignorance, the head has been severed from the body, and both remain in the uterus, the head, when it cannot be extracted first, must be pushed upwards; the crotchet or blunt hook must be fixed under the arm-pit, the arms must be brought down, and the body extracted by fixing the crotchet below the shoulder-blade, on the breast-bone or among the ribs. The head must afterwards be dra n out with the crotchet.

In face-presentations, where it is impossible to alter the position of the fœtus, the double crotchet has been employed: this last, however, is very seldom necessary. The crotchet with a single blade is almost invariably to be preferred.

Cæsarian operation. This consists in making an opening into the abdomen of the mother, in order to extract the child, when delivery cannot be accomplished in any other way. The propriety of having recourse to this operation in any, which in all instances is attended with considerable hazard, has been much agitated; and it must be confessed, that the unhappy event of those cases in which the expedient has recently been tried in Britain, are highly discouraging. In the city of Edinburgh, the cæsarian operation has been performed five times, and none of the females who were operated upon survived many days.

In other countries, however, such has not been the universal result of the trial in question; and the following circumstances have by many been imagined to authorise the adoption of this expedient.

Defective form of the pelvis. Whenever the capacity of the pelvis is so small that its larger diameter does not exceed an inch and a half, a cause of exceedingly unfrequent occurrence, the cæsarian operation has been judged an attempt attended with less danger, even to the mother, than that of embryotomy above described, and as affording a prospect of saving the child it is preferable.

Secondly, imperforations or contracted passages in or about the vagina, have been supposed to indicate this operation; but it has been ascertained that tumours in the vagina may be extirpated, or that imperforations from the parts of the vagina having grown together may be opened, and that therefore such accidents will not justify the operation in question.

When the uterus has been lacerated, and the whole fœtus has escaped into the cavity of the abdomen, the cæsarian operation has been recommended; if, however, even in this case, incision into the abdomen is ever allowable, it should be made at that time alone when a prospect remains of saving the child; as such incision immediately after the uterus has burst, would be almost inevitably attended by the death of the mother. "Should, however, the patient recruit after the accident, and it be found impossible to extract the child through the ordinary passages, a simple incision through the integuments of the abdomen may afford the means of saving the life of the woman."

Cases of ventral conception, or herniæ of the uterus, do not afford sufficient grounds for the attempt. In the former, the event is to be trusted to nature; and in the latter, cases are on record of reduction of the rupture and the safe delivery of the child.

With respect to the position or bulk of the child, the late improvements in obstetrical instruments, &c. have superseded in all cases the necessity of this hazardous expedient, when the obstacle to delivery has been on the part of the fœtus merely. If then in any case the cæsarian operation is justifiable, it appears to be in that only where the extreme contraction of the pelvis does not admit of the operation of embryotomy.

Operation. "First empty the intestines, the rectum, and the vesica urinaria, then lay the patient in a horizontal posture. In making the incision, we must avoid the large arteries in the containing parts. If it was to extend far outwards, considerable branches of the circumflex might be divided; if inwards, the epigastric: so the best place is between the recti muscles, or upon the outside of the rectus. The surgeon should first divide the skin and muscles, and leave the peritonæum entire, until the bleeding from the vessels has entirely ceased. We then open the peritonæum, making first a small incision, and observe if the uterus is contiguous; if it is we divide it with caution. The discharge of blood is smaller than we should expect. We then cut the membranes, separate the placenta to extract the fœtus, discharge the waters, and as soon as the fœtus and secundines are removed, the uterus contracts of itself. Then let the surgeon pass his hand into the cavity of the uterus, and with one or two fingers open the os uteri, that the blood may pass readily out by the vagina. We then shut the womb, sew the containing parts of the abdomen with the glover's stitch, or interrupted suture, at three-fourths of an inch distance, making the needle pass through the skin and part of the muscles, leaving the peritonæum entire; or if there is a considerable effusion of blood and water, stitch all but the under part, introduce into it a soft tent, and cover the whole with a compress. The patient is to be kept on a strict antiphlogistic regimen during the cure." (Extracted from the directions of Dr. Monro, in Dr. Hamilton's System of Midwifery.)

A further operation has been proposed and practised; that of dividing the symphisis pubis, by making an incision with the scalpel through the soft parts, in the direction of the commissure of the ossa pubis, separating afterwards the cartilaginous articulation; and then, by an extension of the thighs, separating the bones, and waiting for the expulsion of the fœtus by natural labour-pains; if these prove insufficient to effect the expulsion, recourse is then directed to be had to extraction by the forceps or by the scissars and crotchet, to turning the child, or to the cæsarian section.

This last, however, which has been called the Sigaultian operation, from its having first been proposed by M. Sigault of Paris, is in no instance to be substituted for that of embryotomy; "which, if not too long delayed, may, in the present improved state of the art, be employed in most cases of distortion, with perfect safety to the mother, who is always justly entitled to the first place in our intentions, and whose valuable life is the most interesting and important object of our regard."

Preternatural labours.

From natural and difficult, we now pass on to consider those labours that are denominated preternatural; which are constituted by the presentation of any part of the child excepting the head and face. The causes of these are obscure. The unnatural position has been attributed to the motions of the infant in the early months of pregnancy, to agitations of the mother at that period, to the form of the child, the quantity of the waters, the too great length or shortness of the navel-string, and other circumstances.

When labour is but little advanced, and before the position of the child can be ascertained by the touch, a preternatural presentation may be anticipated, if the pains are extremely weak, if the membranes are protruded in a form like the finger of a glove, if no part of the child can be discovered when the uterine orifice is much dilated, or if the presenting part gives less resistance than ordinary. If, lastly, when the membranes are ruptured, the meconium comes away with the waters, it is pretty certain that the breech presents, or that the child is dead.

Preternatural presentations may be comprehended under the three following divisions: 1. The presentation of one or both feet, knees, or the breech. 2. When the child lies in a transverse position, and presents with the arm, shoulder, side, back, or abdomen. 3. When one or both arms are protruded before the head.

The first, and by far the most favourable, form of unnatural presentation, is called the Agrippan posture. When one or both feet present, scarcely any thing more is required than if the labour was strictly natural, until the orifice of the womb is sufficiently dilated, and the presenting parts have advanced without the os externum. The woman must then be laid on her side, and the operator is to take hold of one leg above the ancle, and gently endeavour to pull it down in the time of a pain; not in a straight direction, but from side to side, or from the sacrum to the pubes. Upon the remission of the pain, a warm cloth is to be applied to the os externum, and upon the recurrence of a pain, the other leg is to be brought down in the same manner with the first. Now a warm cloth should be wrapped round the feet, so as to leave the toes exposed, in order to direct the turning of the body: if these are directed towards one of the sacro-iliac synchondroses, the child is to be brought along, without any alteration of its position, till it is arrested by the resistance of the shoulders; if, however, the toes should point to the back or belly, the child's body must be gradually turned, till the abdomen is applied to that sacro-iliac synchondrosis to which it is nearest. In turning, the child's body must be firmly grasped with both hands, directing it a little upwards, and laterally, in the time of the pain, favouring that line of direction to which nature appears to incline.

When the breech is entirely protruded, the child must be taken hold of, and gradually extracted, by grasping with the thumbs above the haunches, and the fingers spread upon the groins; as the belly advances, the operator must slide up his hand, and gently draw down a little of the navel-string; and if, after the breech is protruded, the chord is compressed at the os tincæ, the delivery must be earnestly expedited. When the child has

advanced as far as the breast, it ought to be supported by one hand of the operator; the infant being then drawn gently towards one side, two or more fingers of the other hand may be introduced at the opposite into the pelvis, over the back of the shoulder as far as the elbow, to bring down the arm obliquely over the breast. The operator having now shifted hands, the opposite arm must be disengaged in the same manner.

Now the woman is to be allowed rest till another pain or two follow; when, by gently bearing down, the head will generally pass: if, however, this is not the case, a danger of the infant's life will arise from the pressure of the navel-string; if the pulsation of this is extremely weak, the labour must by all means be expedited. Two fingers of the left hand are to be introduced into the mouth of the child, while its body is supported by the hand and arm, and the jaw pulled towards the breast; then pressing down the shoulders with the other hand, the accoucheur must rise from his seat; and having turned the face into the sacral hollow, pull in a direction from before, backwards, with considerable force, alternately raising and depressing the head; when the face descends from the hollow of the sacrum, the delivery must be effected by bringing the back part of the head from under the pubes, by a half-round turn. During this time, pressure should be made by an assistant on the perinæum; caution is required not to injure the child's jaw. If the navel-string interferes, it must be disengaged as easily and expeditiously as possible.

When obstacles prevent the ready advancement of the head, the operator is to forbear his exertion, from time to time. If the resisting bulk is occasioned by hydrocephalus, the teguments, if not burst, may be perforated; and indeed, if the head from any cause is still found too bulky to be protruded or extracted, the perforator and crotchet must be employed.

When only one foot is protruded into the vagina, the other is sometimes prevented from following, by catching on the pubes; this is to be dislodged when it can be done with facility; if not, the attempt should not be made, but the descent of the breech must be waited for. When one or booth knees present, the delivery is nearly the same as in feet-presentation. When the feet protrude along with the breech, the latter is to be thrust up, till the position is connected into a footing-case.

A breech-presentation must be left to nature, till the child is advanced as far as the chest, when the delivery must be accomplished as in a feet-presentation.

When, 2dly, the child lies in a transverse position, and presents with the arm, shoulder, side, back, or abdomen, manual assistance is always requisite; the hand is to be introduced into the uterus in the gentlest manner, the feet sought for, and the delivery accomplished as in foot-presentations: to effect which, the following rules must be attended to. 1. Although the preferable posture for placing the woman is generally on her back, it will sometimes be necessary to turn her on her left side, with the breech placed over the edge of the bed, and the knees kept separate with a folded pillow. 2nd. The exact position of the child is to be ascertained. 3d. The orifice of the uterus should be dilated so as to allow the hand to pass freely, and strong pains are to be waited for. 4th. Should the waters have been discharged, and the parts remain rigid, warm oil should be injected into the uterus, and a full dose of laudanum given. 5th. The hand must be introduced only during the remission of the pain, and the parts should be well lubricated with oil or pomatum. 6th. The expanded palm of the hand is to be employed in pushing up to come at the feet, and not the clenched fists or point of the fingers. 7th. Both feet, if easily reached, should be laid hold of; the hand, if possible, going over the anterior part of the child. 8th. When the hand is within the pelvis, it should not always be moved in the line of the umbilicus, but rather towards one side. 9th. The hand should be passed as far as the middle of the child's body, before the feet are sought for. 10th. If the hand is incapable of passing the presenting part of the child, this should gently be elevated in the pelvis, and then removed to the opposite side.

When the arm presents, the hand of the accoucheur, well lubricated, must be conducted into the uterus, by the course of its side, along the thorax, and towards the opposite side of the pelvis where the head lies; if any difficulty occurs in coming at the feet, the hand must be withdrawn, and the other passed in its stead; if still a passage cannot be procured beyond the shoulder and head, the presenting part must be elevated, and gently pushed on one side, that a hold may be taken of one or both feet, to which, when they have sufficiently advanced, a noose is to be applied; and thus by pulling with one hand, by the noose, and pushing the other, the feet may be brought down, and the delivery effected.

When the shoulder presents, the delivery by turning will be more difficult, in proportion as the presenting part protrudes, and becomes locked in the pelvis. A side-presentation may be ascertained by feeling the ribs; when the back presents, the spine will be felt; and the navel-string if the abdomen. These three last are by no means common occurrences.

The arm-presentations are the most difficult cases in preternatural labour. In this case, the hand of the accoucheur, well lubricated, must be insinuated into the womb, by the direction of the child's arm, the feet are to be searched for and brought down in the best manner circumstances will admit of. If the arm has been long protruded, the os externum swelled and cold, the waters drained off, and the position of the child such as to render the above methods of reduction impossible, the use of the crotchet must be resorted to. When both arms present, which constitutes a less difficult case than when only one protrudes, the delivery must be conducted upon the same principles.

Complex labours.—The principal of these are constituted by plurality of children, monsters, uterine hæmorrhage, convulsions, ruptured uterus, and the prolapse of the navel-string.

Plurality of Children.—Two children at a birth are by no means uncommon occurrences, triplets seldom appear, quadruplets still more rarely; there are, however, instances on record, even of five children from one pregnancy.

When there are two or more children, the size of that one which has been delivered is usually small, the quantity of the liquor amnii inconsiderable, the umbilical chord continues to bleed after division, the placenta is

retained, the labour-pains recur, and the uterine tumour is not sensibly diminished between the stomach and umbilicus.

In twin-cases, the delivery of the second child ought not be precipitated, but deferred till the woman has rested some time, and till the second set of membranes occupy the situation of the former ones; no attempts ought to be made to extract the placenta till after the birth of the remaining child; a second ligature should be placed on that end of the chord next the mother immediately after the birth of the first infant, and a gentle compression made on the abdomen of the woman, which must be gradually tightened as the tumour of the uterus subsides.

The placenta is to be managed in the ordinary manner. In cases of two or more children, it generally separates with much facility, if time has been given for the regular contractions of the uterus. The chord of each placenta should be very gently pulled; and when resistance is met with at the uterine orifice, the fingers must be introduced, in order to loosen their edges.

If, from the very diminutive size of the first and second child, and the remaining of the abdominal tumour, there is reason to expect a third, the accoucheur, after waiting about half an hour for the placenta to separate, without effect, is to introduce his hand; and if a third set of membranes are detected, to break them, and manage the delivery according to the presentation.

Monsters.—These are of various shapes and magnitude; they often, unless very small, occasion much trouble in the delivery. Monstrous productions may be constituted by a preternatural conformation of single parts, such as of the chest, head, abdomen, &c. or there may be two heads, two bodies with one head, &c. These cases, however, are of exceedingly unfrequent occurrence.

Uterine hæmorrhage.—The separation of the placenta is invariably attended with a greater or less discharge of blood; when, however, this exceeds a certain quantity, and symptoms of debility present themselves in rapid succession, no time is to be lost in having recourse to assistance, both internal and external: cloths are to be applied to the orifice of the uterus, dipped in some cold astringent fluid, such as vinegar and water, or red tart wine, which are likewise to be laid on the back and abdomen; and the patient is to be supported by doses of laudanum, port wine, and medicinal astringents.

With respect to the hæmorrhage that arises from the retention of the placenta, in such cases extraction of this substance should be immediately procured, provided the debility does not menace immediate extinction of life; in which case, opium, wine, and cordials, may be given, and the operation of extraction deferred till the strength is in some measure recruited. These are cases, however, in which it is hazardous to lay down any undeviating rule of conduct.

When epileptic fits happen during labour, they are generally to be treated with venesection, immediately succeeded by proper doses of camphor; an expeditious delivery, however, can only be depended on for radical relief.

The rupture of the uterus, which is the most alarming accident that can occur during parturition, is preceded by excessive strong and frequent labour-pains, especially felt on a particular part of the uterus, and when the womb gives way the labour-throes immediately cease; the patient is now affected with vomiting, a discharge of blood is perceived from the vagina, the pulse becomes exceedingly quick, coldness of the extremities succeed, and the patient, seized with a sudden fainting or epileptic fit, sinks into the arms of death.

When this dreadful accident has taken place, the only prospect that we can have of saving the life of the patient, is immediate delivery. This has been had recourse to with success.

When the labour is rendered complex by the prolapse of the umbilical chord, the chord must immediately be replaced, and, during the delivery, carefully retained above the presenting part. The danger in this case arises from the probability of the continued pressure on the chord interrupting the circulation between the mother and the child, before the latter has respired, and thus proving fatal to its life. When, therefore, the accoucheur has succeeded in reducing the protruding funis, delivery ought by all means to be expedited as much as possible.

Management of the lying-in Female.

Most of the complaints which succeed to delivery owe their origin to injudicious nursing, improper cordials, heated apartments, impure air, and a disregard of the mandates of nature, on the part of the female, in neglecting to suckle her offspring. Parturition, unless artificially rendered so, is not usually a dangerous process. The obvious way then to prevent the occurrence of such affections as sometimes follow this process, is to preserve a free circulation of air in the lying-in room, guarding against the admission of partial streams or currents; to forbid the practice of keeping up large fires during the confinement; to avoid indiscriminately taking medicines, either in compliance with custom or the nurse's creed; and to present the breast, as soon as possible, to the new-born infant.

In cases where the patient after delivery is exceedingly feeble, and the succeeding pains are violent, opiates are necessary. Where a tendency to deliquium is perceived, wine and other cordials are given with the utmost propriety; but to give either the one or the other in large quantities, for successive periods, merely because the female is lying-in, is highly improper, and often exceedingly detrimental.

An inordinate quantity of bed-cloths, irritating diet, heated rooms, and deficient ventilation, are regarded by a physician of the most unquestionable authority, and who had ample opportunities for observation, as the principal sources of puerperal diseases. (Heberden.) The miliary eruptions which break out on the skin, either at this or any other period, are almost universally attributed to heating irritating regimen.

When inflammation of the omentum, or other parts in the vicinity of the uterus, occurs soon after delivery, a cool regimen is required, with gentle sudorifics; but in order to obviate the extraordinary tendency to exhaustion and gangrene, discoverable under these circumstances, opium, wine, and bark, must be given in conjunction with diaphoretic medicinals. Puerperal fever, attended with inflammation of parts, is a highly dangerous malady.

When febrile irritation is indirect from a retention of the milk, this fluid must be drawn off by means of glasses, evacuating medicines are to be given, and afterwards absorption promoted by the application to the breast of a simple plaster. If from this cause, from exposure to cold, or from any other accident, actual inflammation is occasioned in one of the breasts, it will be requisite to have recourse to anodyne fomentations, or to emollient poultices. When the irritation of the nipple from the child's suckling is very troublesome, oily applications should be made use of; and of these, that which has been found one of the most efficacious, is the oil of wax (ol. ceræ).

It has been advised by some practitioners to administer drastic purgatives, such as aloes, in case of a suppression of the lochia and consequent fever: the propriety of this expedient, very soon after delivery, would appear extremely problematical. The bowels, however, should by all means be kept open.

With respect to the period of confinement, it has come at length to be pretty generally acknowledged, that the feelings of the patient furnish a safer directory than the patient's almanac.

For the management of the infant, see Infancy.

Explanation of Plates.

Fig. 1. presents a front view of the uterus in situ suspended in the vagina; the anterior parts of the ossa ischium, with the ossa pubis, pudenda, perinæum, and anus, being removed, in order to show the internal parts. A, the last vertebra of the loins. BB, the ossa ilium. CC, the acetabula. DD, the inferior and posterior parts of the ossa ischium. E, the part covering the extremity of the coccyx. F, the inferior part of the rectum. GG, the vagina cut open longitudinally, and stretched on each side of the collum uteri, to show in what manner the uterus is suspended in the same. HH, part of the vesica urinaria stretched on each side of the vagina, and inferior parts of the fundus uteri. I, the collum uteri. K, the fundus uteri. LL, the tubi Fallopiani, and fimbriæ. MM, the ovaria. NN, the ligamenta lata and rotunda. OO, the superior part of the rectum.

Fig. 2. presents a front view of the uterus in the beginning of the first month of pregnancy; the anterior part being removed, that the embryo may appear through the amnios, the chorion being dissected off. A, the fundus uteri. B, the collum uteri, with a view of the rugous canal that leads to the cavity of the fundus. C, the os uteri.

Fig. 3. the same view and section of the parts as in fig. 1., shows the uterus as it appears in the second or third month of pregnancy. F, the anus. G, the vagina, with its plicæ. HH, the posterior and inferior part of the urinary bladder extended on each side; the anterior and superior part being removed. II, the mouth and neck of the womb, as raised up when examining the same by the touch, with one of the fingers in the vagina. KK, the uterus as stretched in the second or third month, containing the embryo, with the placenta adhering to the fundus.

Fig. 4. in the same view and section of the parts with the former figures, represents the uterus in the eighth or ninth month of pregnancy. A, the uterus as stretched to near its full extent, with the waters, and containing the fœtus entangled in the funis, the head presenting at the upper part of the pelvis. BB, the superior part of the ossa ilium. CC, the acetabula. DD; the remaining posterior parts of the ossa ischium. E. the coccyx. F, the inferior part of the rectum. GGG, the vagina stretched on each side. H, the os uteri, the neck being stretched to its full extent, or entirely obliterated. II, part of the vesica urinaria. KK, the placenta, at the superior and posterior part of the uterus. LL, the membranes. M, the funis umbilicalis.

Fig. 5. presents a front view of twins in utero in the beginning of labour. A, the uterus as stretched, with the membranes and waters. BB, the superior parts of the ossa ilium. CC, the acetabula. DD, the ossa ischium. E, the coccyx. F, the lower part of the rectum. GG, the vagina. H, the os internum stretched open about a finger's breadth, with the membranes and waters in time of labour-pains. II, the inferior part of the uterus, stretched with the waters which are below the head of the child that presents. KK, the two placentas adhering to the posterior part of the uterus, the two fœtuses lying before them, one with its head in a proper position at the inferior part of the uterus, and the other situated preternaturally with the head to the fundus; the bodies of both are here entangled in their proper funis, which frequently happens in the natural as well as preternatural positions. LLL, the membranes belonging to each placenta.

Fig. 6. exhibits, in a lateral view and longitudinal division of the parts, the gravid uterus when labour is somewhat advanced. A, the lowest vertebra of the back; the distance from which to the last-mentioned vertebra is here shown by dotted lines. CC, the usual thickness and figure of the uterus when extended by the waters at the latter part of pregnancy. D, the same contracted and grown thicker after the waters are evacuated. EE, the figure of the uterus when pendulous. FF, the figure of the uterus when stretched higher than usual, which generally occasions vomitings and difficulty of breathing. G, the os pubis of the left side. HH, the os internum. I, the vagina. K, the left nympha. L, the labium pudendi of the same side. M, the remaining portion of the bladder. N. the anus. OP, the left hip and thigh.

Fig. 7. exhibits the forehead of the fœtus turning backwards to the os sacrum, and the occiput below the pubes; by which means the narrow part of the head is to the narrow part of the pelvis, that is, between the inferior parts of the ossa ischium. A, the uterus contracted closely to the fœtus after the waters are evacuated. BCD, the vertebræ of the loins, os sacrum, and coccyx. E, the anus. F, the left hip. G, the perinæum. H, the os externum beginning to dilate. I, the os pubis of the left side. K, the remaining portion of the bladder. L, the posterior part of the os uteri.

Fig. 8. presents a lateral internal view of a distorted pelvis, divided longitudinally, with the head of a fœtus of the seventh month passing the same. ABC, the os sacrum and coccyx. D, the os pubis of the left side. E, the tuberosity of the os ischium of the same side.

Fig. 9. presents a side view of a distorted pelvis, divided longitudinally, with the head of a full-grown fœtus squeezed into the brim, the parietal bones decussating each other, and compressed into a conical form. ABC,

the os sacrum and coccyx. D, the os pubis of the left side. E, the tuberosity of the os ischium. F, the processus acutus. G, the foramen magnum.

Fig. 10. shows in what manner the head of the fœtus is helped along with the forceps, when it is necessary for the safety of either mother or child. A,A,B,C, the vertebræ of the loins, the os sacrum, and coccyx. D, the os pubis of the left side. E, part of the bladder. FF, the intestinum rectum. GGG, the uterus, H, the mons Veneris. I, the clitoris with the left nympha. X, the corpus cavernoscum clitoridis. V, the meatus urinarius. K, the left labium pudendi. L, the anus. N, the perinæum. QP, the left hip and thigh. R, the skin and muscular part of the loins.

Fig. 11. shows in a lateral view the face of the child, forced down into the lower part of the pelvis, the chin below the pubes, and the vertex in the cavity of the os sacrum; the waters being all discharged, the uterus appears closely attached to the body of the child.

Fig. 12. shows the head of the child in the same position as the eleventh figure. AB, the vertebræ of the loins, os sacrum, and coccyx. C, the os pubis of the left side. D, the lower part of the rectum. E, the perinæum. F, the left labium pudendi. GGG, the uterus.

Fig. 13. shows the head of the fœtus, by strong labour-pains, squeezed into a longish form, with a tumour on the vertex, from long compression of the head in the pelvis. K, the tumour on the vertex. L, the forceps. M, the urinary bladder much distended with a large quantity of urine, from the long pressure of the head against the urethra. N. the under part of the uterus. OO, the os uteri.

Fig. 14. exhibits a front view of the pelvis, the breech of the fœtus presenting, and dilating the os internum, the membranes having been prematurely ruptured.

Fig. 15. represents in a front view of the pelvis, the fœtus compressed by the contraction of the uterus into a round form, the fore parts of the former being towards the inferior part of the latter, and one foot and hand fallen down into the vagina. In this figure, the anterior part of the pelvis is removed by a longitudinal section, through the middle of the foramen magnum. AA, the superior portion of the ossa ilium. BB, the uterus. C, the mouth of the uterus shooting and appearing in OOOO the vagina. D, the inferior and posterior part of the os externum. EEEE, the remaining parts of the ossa pubis and ischium. FFF, the adipose membrane.

Fig. 16. represents the forceps and blunt hook. *a*, the straight forceps. *b*, the posterior part of a single blade. *c*, the blunt hook; which is employed to assist the extraction of the head after the cranium is opened, by introducing the small end along the ear on the outside of the head, to above the under jaw, where the point is to be fixed; the other extremity of the hook being held with one hand, while two fingers of the other are to be introduced into the opening. The small end is useful in abortions, to draw down the secundines when they are not expelled by labour-pains, or cannot be extracted by the fingers. The large hook at the opposite end is useful to assist the extraction of the body when the breech presents, but should be used with much caution.

Fig. 17. A represents the whole bone fillet, which, when the operator is not provided with forceps, may sometimes be useful in laborious cases. BB, two views of a pessary for the prolapsus uteri. C, a round pessary which is in more general use than the former. DD, two views of a female catheter.

Fig. 18. *a*, represents a pair of curved crotchets, locked in the same manner as the forceps; the dotted lines indicate a sheath, contrived to defend the point till it is introduced sufficiently high. *b*, gives a view of the back part of one of the crotchets. *c*, a front view of the point. *d*, the scissars for perforating the cranium, in very narrow and distorted pelvises.

MIGRATION, *of birds*. It has been generally believed, that many different kinds of birds annually pass from one country to another, and spend the summer or the winter where it is most agreeable to them; and that even the birds of Great Britain will seek the most distant southern regions of Africa, when directed by a peculiar instinct to leave their own country. It has long been an opinion pretty generally received, that swallows reside during the winter season in the warm southern regions; and Mr. Adanson particularly relates his having seen them at Senegal, when they were obliged to leave this country. But besides the swallow, Mr. Pennant enumerates many other birds which migrate from Britain at different times of the year, and are then to be found in other countries; after which they again leave these countries and return to Britain.

1. Crows. Of this genus the hooded crow migrates regularly with the woodcock. It inhabits North Britain the whole year; a few are said annually to breed on Dartmoor, in Devonshire. It breeds also in Sweden and Austria; in some of the Swedish provinces it only shifts its quarters, in others it resides throughout the year. Our author is at a loss for the summer retreat of those birds which visit us in such numbers in winter, and quit our country in the spring; and for the reason why a bird whose food is such that it may be found at all seasons in this country, should leave us.

2. Cuckoo. disappears early in autumn; the retreat of this and the following bird is quite unknown to us.

3. Wryneck, is a bird that leaves us in the winter. If its diet is ants alone, as several assert, the cause of its migration is very evident. This bird disappears before winter, and revisits us in the spring, a little earlier than the cuckoo.

4. Hoopoe. Comes to England but by accident. Mr. Pennant once indeed heard of a pair that attempted to make their nest in a meadow at Selborne, Hampshire, but were frightened away by the curiosity of people. It breeds in Germany.

5. Grouse. The whole tribe, except the quail, live here all the year round; that bird either leaves us, or else retires towards the sea-coasts.

6. Pigeons. Some few of the ring-doves breed here; but the multitude that appear in winter are so disproportioned to what continue here the whole year, as to make it certain that the greatest part quit the country in the spring. It is most probable they go to Sweden to breed, and return thence in autumn: as Mr Ekmark informs us, they entirely quit that country before winter. Multitudes of the common wild pigeons also make the northern retreat, and visit us in winter; though numbers

breed in the high cliffs in all parts of this island. The turtle also probably leaves us in the winter, at least changes its place, removing to the southern counties.

7. Stare, breeds here. Possibly several remove to other countries for that purpose, since the produce of those that continue here seems uequal to the clouds of them that appear in winter. It is not unlikely that many migrate into Sweden, whither Mr. Berger observes they return in spring.

8. Thrashes. The fieldfare and the redwing breed pass their summers in Norway and other cold countries; their food is berries, which abounding in our kingdoms tempt them hither in the winter. These two, and the Royston crow, are the only land birds that regularly and constantly migrate into England, and do not breed here. The hawfinch and crossbill come hither at such uncertain times as not to deserve the name of birds of passage.

9. Chatterer. The chatterer appears annually about Edinburgh in flocks during winter, and feeds on the berries of the mountain ash. In South Britain it is an accidental visitant.

10. Grosbeaks. The grosbeak and crossbill come hither but seldom; they breed in Austria. The pine grosbeak probably breeds in the forests of the Highland of Scotland.

11. Buntings. All the genus inhabit England throughout the year, except the greater brambling, which is forced hither from the north in very severe seasons.

12. Finches. All continue in some part of these kingdoms, except the siskin, which is an irregular visitant, said to come from Russia. The linnets shift their quarters, breeding in one part of this island, and remove with their young to others. All finches feed on the seeds of plants.

13. Larks, fly-catchers, wagtails, and warblers. All these brds feed on insects and worms; yet only part of them quit these kingdoms, though the reason of migration is the same to all. The nightingale, black-cap, flycatcher, willow-wren, wheatear, and white-throat, leave us before winter, while the small and delicate golden crested wren braves our severest frosts. The migrants of this genus continue longest in Great Britain in the southern counties, the winter in those parts being later than in those of the north; Mr. Stillingfleet having observed several wheatears in the isle of Purbeck on the 18th of November. As these birds are incapable of very distant flights, Spain, or the south of France, is probably their winter assylum.

14. Swallow and goat-sucker. Every species disappears at the approach of winter.

Water-fowl, cloven-footed.

15. Herons. The white heron is an uncommon bird, and visits us at uncertain seasons; the common kind and the bittern never leave us.

16. Curlews. The curlew breeds sometimes on our mountains; but considering the vast flights that appear in winter, it is probable that the greater part retire to other countries; the whimbrel breeds on the Grampian hills, in the neighbourhood of Invercauld.

17. Snipes. The woodcock breeds in the moist woods of Sweden, and other cold countries. Some snipes breed here; but the greatest part retire elsewhere, as do every other species of this genus.

18. Sandpipers. The lapwing continues here the whole year; the ruff breeds here, but retires in winter; the redshank and sandpiper breed in this country, and reside here. All the others absent themselves during summer.

19. Plovers and oyster-catchers. The long-legged plover and the sanderling visit us only in winter: the dottrel appears in spring and in autumn; yet what is very singular, we do not find it breeds in South Britain. The oyster-cather lives with us the whole year. The Norfolk plover and the sea-lark breed in England. The green plover breeds on the mountains of the north of England, and on the Grampian hills.

We must here remark, that every species of the genera of curlews, woodcocks, sandpipers, and plovers, that forsake us in the spring, retire to Sweden, Poland, Prussia, Norway, and Lapland, to breed; as soon as the young can fly, they return to us again, because the frosts which set in early in those countries totally deprive them of the means of subsisting; as the dryness and hardness of the ground, in general, during our summer, prevent them from penerating the earth with their bills, in search of worms which are the natural food of these birds.

20. Rails and gallinules. Every species of these two genera continue with us the whole year; the land-rail excepted, which is not seen here in winter. It likewise continues in Ireland only during he summer-mouths, when it is very numerous.

Finned-footed Water-birds.

21. Phalaropes visit us but seldom; their breeding-place is Lapland and other arctic regions.

22. Grebes. The great-crested grebe, the black and white grebe, and little grebe, breed with us, and never migrate; the others visit us accidentally, and breed in Lapland.

Web-footed Birds.

23. Avoset. Breed near Fossdike in Lincolnshire, but quit their quarters in winter. They are then shot in different parts of the kingdom; which they visit not regularly, but accidentally.

24. Auks and guillemots. The great auk or pinguin sometimes breeds in St. Kilda. The auk, the guillemot, and puffin, inhabit most of the maritime cliffs of Great Britain, in amazing numbers, during summer. The black guillemot breeds in the Bass Isle, and in St. Kilda, and sometimes in Llandinno rocks. We are at a loss for the breeding-place of the other species; neither can we be very certain of the winter residence of any of them, except of the lesser guillemot and black-billed auk, which, during winter, visit in vast flocks the frith of Forth.

25. Divers, chiefly breed in the lakes of Sweden and Lapland, and in some countries near the pole; but some of the red-throated divers, the northern, and the imber, may breed in the north of Scotland and its isles.

26. Tems. Every species breeds here, but leaves us in the winter.

27. Petrels. The fulmar breeds in the isle of St. Kilda, and continues there the whole year except September and part of October. The shearwater visits the Isle of Man in April; breeds there; and, leaving it in August or the beginning of September, disperses over all parts of the Atlantic ocean. The stormfinch is seen at all distances from land on the same vast watery tract; nor is ever found

near the shore except by some very rare accident, unless in the breeding-season. Mr. Pennant found it on some little rocky isles, off the north of Skye. It also breeds in St. Kilda. He suspects too that it nestles on the Blasquet isles off Kerry, and that it is the gourder of Mr. Smith.

28. Mergansers. This whole genus is mentioned among the birds that fill the Lapland lakes during summer. Mr. Pennant has seen the young of the red-breasted in the north of Scotland; a few of these, and perhaps of the goosanders, may breed there.

29. Ducks. Of the numerous species that form this genus, we know of few that breed here; the swan and goose, the shield-duck, the eider-duck, a few shovellers, garganies, and teals, and a very small portion of the wild ducks.

The rest contribute to form that amazing multitude of water-fowl that annually repair from most parts of Europe to the woods and lakes of Lapland and other arctic regions, there to perform the functions of incubation and nutrition in full security. They and their young quit their retreat in September, and disperse themselves over Europe. With us they make their appearance the beginning of October; circulate first round our shores; and, when compelled by severe frost, betake themselves to our lakes and rivers. Of the web-footed fowl there are some of harder constitutions than others; these endure the ordinary winters of the more northern countries; but when the cold reigns there with more than common rigour, they repair for shelter to these kingdoms: this regulates the appearance of some of the diver kind, as also of the wild swans, the swallow-tailed shield-duck, and the different sorts of goosanders which then visit our coasts. Barentz found the barnacles with their nests in great numbers in Nova Zembla.

30. Corvorants. The corvorants and shag breed on most of our high rocks: the gannet in some of the Scotch isles, and on the coast of Kerry; the two first continue on our shores the whole year. The gannet disperses itself all round the seas of Great Britain, in pursuit of the herring and pilchard, and even as far the Tagus to prey on the sardina.

MILE, a measure of length or distance, containing eight furlongs.

The English statute-mile is fourscore chains, or 1760 yards; that is, 5280 feet. See CHAIN, YARD, and FOOT.

We shall here give a table of the miles in use among the principal nations of Europe, in geometrical paces, 60,000 of which make a degree of the equator.

	Geometrical paces.
Mile of Russia - - -	750
of Italy - - -	1000
of England - - -	1250
of Scotland and Ireland -	1500
of Poland - - -	3000
of Spain - - -	3428
of Germany - - -	4000
of Sweden - - -	5000
of Denmark - - -	5000
of Hungary - - -	6000

MILIARY FEVER, a malignant fever, so called from the eruption of certain pustules resembling millet-seeds. See MEDICINE.

MILIUM, MILLET, a genus of the digynia order, in the triandria class of plants; and in the natural method ranking under the 4th order, gramina. The calyx is bivalved and uniflorous; the corolla is very short; the stigmata pencil-like. There are 12 species, of which the most remarkable is the effusum, or common millet.

MILK, is a fluid secreted by the female of all those animals denominated mammalia, and intended evidently for the nourishment of her offspring.

The milk of every animal has certain peculiarities which distinguish it from every other milk. But the animal whose milk is most made use of by man as an article of food, and with which, consequently, we are best acquainted, is the cow. Chemists, therefore, have made choice of cow's milk for their experiments.

Milk is an opaque fluid, of a white colour, a slight peculiar smell, and a pleasant sweetish taste. When newly drawn from the cow, it has a taste very different from that which it acquires after it has been kept for some hours.

It is liquid, and wets all those substances which can be moistened in water; but its consistence is greater than that of water, and it is slightly unctuous. Like water, it freezes when cooled down to about 30°; but Parmentier and Deyeux, to whom we are indebted for by far the completest account of milk hitherto published, found that its freezing-point varies considerably in the milk of different cows, and even of the same cow at different times. Milk boils also when sufficiently heated; but the same variation takes place in the boiling-point of different milks, though it never deviates very far from the boiling-point of water. Milk is specifically heavier than water, and lighter than blood; but the precise degree cannot be ascertained, because almost every particular milk has a specific gravity peculiar to itself.

When milk is allowed to remain for some time at rest, there collects on its surface a thick unctuous yellowish-coloured substance, known by the name of cream. The cream appears sooner on milk in summer than in winter, evidently owing to the difference of temperature. In summer, about four days of repose are necessary before the whole of the cream collects on the surface of the liquid; but in winter it requires at least double the time.

After the cream is separated, the milk which remains is much thinner than before, and it has a bluish-white colour. If it is heated to the temperature of 100°, and a little rennet (which is water digested with the inner coat of a calf's stomach, and preserved with salt) is poured into it, coagulation ensues; and if the coagulum is broken, the milk very soon separates into two substances; a solid white part known by the name of curd, and a fluid part called whey.

Thus we see that milk may be easily separated into three parts; namely, cream, curd, and whey.

1. Cream is of a yellow colour, and its consistence increases gradually by exposure to the atmosphere. In three or four days it becomes so thick that the vessel which contains it may be inverted without risking any loss. In eight or ten days more, its surface is covered over with mucors and byssi, and it has no longer the flavour of cream, but of very fat cheese. This is the process for making what in this country is called a cream-cheese.

Cream possesses many of the properties of an oil. It is specifically lighter than water; it has an unctuous feel; stains clothes precisely in the manner of oil; and if it is kept fluid, it contracts at last a taste which is very analogous to the rancidity of oils. When kept boiling for some time, a little oil makes its appearance, and floats upon its surface. Cream is neither soluble in alcohol nor in oils. These properties are sufficient to show us, that it contains a quantity of oil; but this oil is combined with a part of the curd, and mixed with some serum; cream, then, is composed of a peculiar oil, curd, and serum. The oil may be easily obtained separate by agitating the cream for a considerable time. This process, known to every body, is called churning. After a certain time, the cream separates into two portions; one fluid, and resembling creamed milk; the other solid, and called butter.

Butter is of a yellow colour, possesses the properties of an oil, and mixes readily with other oily bodies. When heated to the temperature of 96°, it melts, and becomes transparent; if it is kept for some time melted, some curd and water, or whey, separates from it, and it assumes exactly the appearance of oil. But this process deprives it in a great measure of its peculiar flavour.

When butter is kept for a certain time, it becomes rancid, owing in a good measure to the presence of these foreign ingredients; for if butter is well-washed, and a great portion of these matters separated, it does not become rancid nearly so soon as when it is not treated in this manner. It was formerly supposed that this rancidity was owing to the developement of a peculiar acid; but Parmentier and Deyeux have shown that no acid is present in rancid butter. When butter is distilled, there comes over water an acid, and an oil, at first fluid, but afterwards concrete. The carbonaceous residuum is but small.

Butter may be obtained by agitating cream newly taken from milk, or even by agitating milk newly drawn from the cow; but is is usual to allow cream to remain for some time before it is churned. Now cream, by standing, acquires a sour taste; butter, therefore, is commonly made from sour cream. Fresh cream requires at least four times as much churning before it yields its butter, as sour cream does; consequently cream acquires, by being kept for some time, new properties, in consequence of which it is more easily converted into butter. When very sour cream is churned, every one who has paid the smallest attention must have perceived, that the buttermilk, after the churning, is not nearly so sour as the cream had been. The butter, in all cases, is perfectly sweet; consequently the acid which had been evolved has in a great measure disappeared during the process of churning. It has been ascertained, that cream may be churned, and butter obtained, though the contact of atmospheric air should be excluded. On the other hand, it has been affirmed, that when cream is churned in contact with air, it absorbs a considerable quantity of it.

In all cases there is a considerable extrication of gas during the churning of butter. From the phenomena, it can scarcely be doubted that this gas is carbonic acid. Dr. Young affirms, that during the churning there is an increase of temperature amounting to four degrees.

These facts show that considerable chemical changes go on during the process of churning. The agitation keeps the different substances in contact, and enables them to act upon each other. The expulsion of carbonic acid accounts for the diminution of acidity after churning; while the other phenomena would lead us to suppose that the cream, before it becomes butter, unites to a new portion of oxygen.

The affinity of the oil of cream for the other ingredients is such, that it never separates completely from them. Not only are curd and whey always found in the cream, but some of this oil is constantly found in creamed milk and whey; for it has been ascertained by actual experiment, that butter may be obtained by churning whey. 27 Scotch pints of whey yield at an average about a pound of butter. This accounts for a fact well known to those who superintend dairies, that a good deal more butter may be obtained from the same quantity of milk, provided it is churned as drawn from the cow, than when the cream alone is collected and churned.

The buttermilk, as Parmentier and Deyeux ascertained by experiment, possesses precisely the properties of milk deprived of cream.

2. Curd, which may be separated from creamed milk by rennet, has many of the properties of coagulated albumen. It is white and solid; and when all the moisture is squeezed out, it has a good deal of brittleness. It is insoluble in water; but pure alkalies and lime dissolve it readily, especially when assisted by heat; and when fixed alkali is used, a great quantity of ammonia is emmitted during the solution. The solution of curd in soda is of a red colour, at least if heat is employed; owing probably to the separation of charcoal from the curd by the action of the alkali. Indeed, when a strong heat has been used, charcoal precipitates as the solution cools. The matter dissolved by the alkali may be separated from it by means of an acid; but it has lost all the properties of curd. It is of a black colour, melts like tallow by the application of heat, leaves oily stains on paper, and never acquires the consistence of curd. Hence it appears that curd, by the action of a fixed alkali, is decomposed, and converted into two new substances; ammonia, and oil or rather fat.

Curd is soluble also in acids. If, over curd newly precipitated from milk, and not dried, there are poured eight parts of water, containing as much of any of the mineral acids as gives it a sensibly acid taste, the whole is dissolved after a little boiling. Acetic acid and lactic acid do not dissolve curd, when very much diluted; but these acids, when concentrated, dissolve it readily, and in considerable quantity. It is remarkable enough, that concentrated vegetable acids dissolve curd readily, but have very little action on it when they are very much diluted; whereas the mineral acids dissolve it when much diluted; but when concentrated, have either very little effect on it, as sulphuric acid, or decompose it, as nitric acid. By means of this last acid, as Berthollet discovered, a quantity of azotic gas may be obtained from curd.

Curd, as is well known, is used in making cheese; and the cheese is the better the more it contains of cream, or of that oily matter which constitutes cream. It is well known to cheesemakers, that the goodness of it depends in a great measure on the manner of separating the whey

from the curd. If the milk is much heated, the coagulum broken in pieces, and the whey forcibly separated, as is the practice in many parts of Scotland, the cheese is scarcely good for any thing; but the whey is delicious, especially the whey last squeezed out, and butter may be obtained from it in considerable quantity. This is a full proof that nearly the whole creamy part of the milk has been separated with the whey. Whereas if the milk is not too much heated (about 100 degrees is sufficient), if the coagulum is allowed to remain unbroken, and the whey separated by very slow and gentle pressure, the cheese is excellent; but the whey is almost transparent, and nearly colourless.

Good cheese melts at a moderate heat; but bad cheese, when heated, dries, curls, and exhibits all the phenomena of burning horn. Hence it is evident, that good cheese contains a quantity of the peculiar oil which constitutes the distinguishing characteristic of cream; whence its flavour and smell.

This resemblance of curd and albumen makes it probable that the coagulation of milk and albumen depends upon the same cause. Heat, indeed, does not coagulate milk, because the curd in it is diluted with too large a quantity of water; but if milk is boiled in contact with air, a pellicle soon forms on its surface, which has the properties of curd. If this pellicle is removed, another succeeds; and by continuing the boiling, the whole of the curdy matter may be separated from milk. When this pellicle is allowed to remain, it falls at last to the bottom of the vessel; where, being exposed to a greater heat, it becomes brown, and communicates to milk that disagreeable taste which, in this country, is called a *singed* taste. It happens more readily when milk is boiled along with rice, flour, &c.

If to boiling milk there is added as much of any neutral salt as it is capable of dissolving, or of sugar, or of gum arabic, the milk coagulates and the curd separates. Alcohol also coagulates milk; as do all acids, rennet, and the infusion of the flowers of artichoke and of the thistle. If milk is diluted with ten times its weight of water, it cannot be made to coagulate at all.

3. Whey, after being filtred to separate a quantity of curd which still continues to float through it, is a thin pellucid fluid, of a yellowish-green colour and pleasant sweetish taste, in which the flavour of milk may be distinguished. It always contains some curd: nearly the whole may be separated by keeping the whey for some time boiling; a thick white scum gathers on the surface, which is known by the name of skim-curd. When this scum, which consists of the curdy part, is carefully separated, the whey, after being allowed to remain at rest for some hours, to give the remainder of the curd time to precipitate, is decanted off almost as colourless as water, and scarcely any of the peculiar taste of milk can be distinguished in it. If it is now slowly evaporated, it deposits at last a number of white-coloured crystals, which are sugar of milk. Towards the end of the evaporation, some crystals of muriat of potass and of muriat of soda make their appearance. According to Scheele, it contains also a little phosphat of lime, which indeed may be precipitated by ammonia.

After the salts have been obtained from whey, what remains concretes into a jelly on cooling. Hence it follows that whey also contains gelatine. Whey, then, is composed of water, sugar of milk, gelatine, muriat of potass, and phosphat of lime. The other salts which are sometimes found in it, are only accidentally present.

If whey is allowed to remain for some time, it becomes sour, owing to the formation of a peculiar acid known by the name of lactic acid. It is to this property of whey that we are to ascribe the acidity which milk contracts; for neither curd nor cream, perfectly freed from serum, seems susceptible of acquiring acid properties. Hence the reason also that milk, after it becomes sour, always coagulates. Boiled milk has the property of continuing longer sweet, but it is singular enough that it runs sooner to putrefaction, than ordinary milk.

The acid of milk differs considerably from the acetic; yet vinegar may be obtained from milk by a very simple process. If to somewhat more than 8 lbs. troy of milk six spoonfuls of alcohol are added, and the mixture well corked is exposed to a heat sufficient to support fermentation, provided attention is paid to allow the carbonic acid gas to escape from time to time, the whey, in about a month, will be found converted into vinegar.

Milk is almost the only animal substance which may be made to undergo the vinous fermentation, and to afford a liquor resembling wine or beer, from which alcohol may be separated by distillation. This singular fact seems to have been first discovered by the Tartars; they obtain all their spirituous liquors from mare's milk. It has been ascertained, that milk is incapable of being converted into wine till it has become sour; after this nothing is necessary but to place it in the proper temperature; the fermentation begins of its own accord, and continues till the formation of wine is completed. Scheele had showed that milk was capable of fermenting, and that a great quantity of carbonic acid gas was extricated from it during this fermentation; but he did not suspect that the result of this fermentation was the formation of an intoxicating liquor similar to wine. The Tartars call the vinous liquid which they prepare koumiss. A very exact account of its preparation and medical uses has been published by Dr. Guthrie.

When milk is distilled by the heat of a water-bath, there comes over water having the peculiar odour of milk: which putrefies; and consequently contains, besides mere water, some of the other constituent parts of milk. After some time the milk coagulates, as always happens when hot albumen acquires a certain degree of concentration. There remains behind a thick unctuous yellowish-white substance, to which Hoffman gave the name of franchippan. This substance, when the fire is increased, yields at first a transparent liquid, which becomes gradually more coloured; some very fluid oil comes over; then ammonia, an acid, and at last a very thick black-oil. Towards the end of the process carbureted hydrogen gas is disengaged. There remains in the retort a coal which contains carbonat of potass, muriat of potass, and phosphat of lime; and sometimes magnesia, iron, and muriat of soda.

Thus we see that cow's milk is composed of the following ingredients:

1. Water,	4. Gelatine,
2. Oil,	5. Sugar of milk.
3. Curd,	6. Muriat of soda,

7. Muriat of potass, 9. Phosphat of lime.
8. Sulphur,

The milk of all other animals, as far as it has hitherto been examined, consists nearly of the same ingredients: but there is a very great difference in their proportion.

Woman's milk has a much sweeter taste than cow's milk. When allowed to remain at rest for a sufficient time, a cream gathers on its surface. This cream is more abundant than in cow's milk, and its colour is usually much whiter. After it is separated, the milk is exceedingly thin; and has the appearance rather of whey with a blueish-white colour, than of creamed milk.

None of the methods by which cow's milk is coagulated succeed in producing the coagulation of woman's milk. It is certain, however, that it contains curd: for if it is boiled, pellicles form on its surface, which have all the properties of curd. Its not coagulating, therefore, must be attributed to the great quantity of water with which the curd is diluted.

Though the cream is churned ever so long, no butter can be obtained from it; but if, after being agitated for some hours, it is allowed to remain at rest for a day or two, it separates into two parts: a fluid which occupies the inferior part of the vessel, pellucid and colourless like water; and a thick white unctuous fluid which swims on the surface. The lowermost fluid contains sugar of milk and some curd; the uppermost does not differ from cream except in consistence. The oily part of the cream, then, cannot be separated by agitation from the curd. This cream contains a greater portion of curd than the cream of cow's milk.

When this milk, after the curd is separated from it, is slowly evaporated, it yields crystals of sugar of milk and of muriat of soda. The quantity of sugar is rather greater than in cow's milk. According to Haller, the sugar obtained from cow's milk is to that obtained from an equal quantity of woman's milk as 35 to 58, and sometimes as 37 to 67, and in all the intermediate ratios.

Thus it appears that woman's milk differs from that of cow's in three particulars:

It contains a much smaller quantity of curd. Its oil is so intimately combined with its curd that it does not yield butter. It contains rather more sugar of milk.

Parmentier and Deyeux ascertained, that the quantity of curd in woman's milk increases in proportion to the time after delivery. Nearly the same thing has been observed with respect to cow's milk.

Ass's milk has a very strong resemblance to human milk. It has nearly the same colour, smell and consistence. When left at rest for a sufficient time, a cream forms upon its surface, but by no means in such abundance as in woman's milk. This cream, by very long agitation, yields a butter, which is always soft, white, and tasteless; and, what is singular, very readily mixes again with the buttermilk; but it may be again separated by agitation, while the vessel which contains it is plunged in cold water. Creamed ass's milk is thin, and has an agreeable sweetish taste. Alcohol and acids separate from it a little curd, which has but a small degree of consistence. The serum yields sugar of milk and muriat of lime.

Ass's milk therefore differs from cow's milk in three particulars:

Its cream is less abundant and more insipid. It contains less curd. It contains more sugar of milk: the proportion is 35 to 80.

Goat's milk, if we except its consistence, which is greater, does not differ much from cow's milk. Like that milk it throws up abundance of cream, from which butter is easily obtained. The creamed milk coagulates just as cow's milk, and yields a greater quantity of curd. Its whey contains sugar of milk, muriat of lime, and muriat of soda.

Ewe's milk resembles almost precisely that of the cow. Its cream is rather more abundant, and yields a butter which never acquires the consistence of butter from cow's milk. Its curd has a fat and viscid appearance, and is not without difficulty made to assume the consistence of the curd of cow's milk. It makes excellent cheese.

Mare's milk is thinner than that of the cow, but scarcely so thin as human milk. Its cream cannot be converted into butter by agitation. The creamed milk coagulates precisely as cow's milk, but the curd is not so abundant. The serum contains sugar of milk, sulphat of lime, and muriat of lime.

MILK-WAY, in astronomy, a broad track or path, encompassing the whole heavens, distinguishable by its white appearance: whence it obtains its name. See ASTRONOMY.

MILL, a machine or engine for grinding corn, &c. of which there are several kinds, according to the various methods of applying the moving power; as water-mills, wind-mills, mills worked by horses, &c.

In water-mills the momentum of the water is the moving power; and the attrition of the two stones in grinding is the force to be overcome. Of these there are two kinds, viz. those where the force of the water is applied above the wheel, and those where it is applied below the wheel; the former being called overshot, and the latter undershot mills: and to these we may add a breast-mill, where the water strikes against the middle of the wheel.

Few people are ignorant that corn is ground by two mill-stones, placed one above the other, without touching. The lower, or nether, mill-stone, is immoveable; but the upper one turns upon a spindle. The opposite surfaces of the two stones, which act to grind the corn, are not plane or flat; but the upper one is hollow, and the under one swells upwards; each of them being of a conic figure, whose axis indeed is very short in proportion to the diameter of its base: for the upper one, being six feet in diameter, is hollowed but about one inch at its centre; and the lower one rises but about three-fourths of an inch. These two mill-stones come nearer and nearer towards their circumference, whereby the corn that falls from the hopper has room to insinuate between them as far as two-thirds of the radius, which is the place where it begins to be ground, and where it makes the greatest resistance that it is capable of; the space between the stones being in that place but about two-thirds or three-fourths of the thickness of a grain of corn. But as the millers have the means of raising or sinking the upper stone a little, they can proportion its distance from the lower one, according as they would have the flour finer or coarser.

The circular motion of the upper mill-stone brings the corn out of the hopper by jerks, and causes it to recede from the centre towards the circumference; where being

quite reduced to flour, it is thrown out of the mill, by the centrifugal force of the stone, through a hole provided on purpose.

As the water acts upon an overshot-mill both by impulse and weight, so does it likewise upon a breast-mill, or that where the water comes upon the breast or middle part of the wheel: and here, though the weight of the water is not so great as in the overshot mill, being contained in the buckets of the lower quarter only; yet the impulse of the water is much greater, the height of the water being increased nearly the semidiameter of the great wheel, all other things being equal. If the height of the water remains the same, the aperture of the penstock, or flood-gate, must be enlarged to nearly twice the area, that the force may be the same; so that to produce the same effect, twice as much water is necessary for a breast-mill as for an overshot one, every thing else being the same.

As to the undershot-mill, it is evident that there can be only the impulse from the water; and therefore the height of the water remaining the same, there must be a larger aperture of the penstock for the discharge of a greater quantity of water in the same time, in order to produce the same effect, as in the overshot, or breast-mill: whence a greater expense of water will be made here than in any other mill, and can only be supplied for a constancy by a river; and where this can be had, the undershot is the easiest, cheapest, and most simple structure a mill is capable of.

Mr. Smeaton has considered the best methods of constructing all these mills from machines and models made on purpose; but, conscious of the inferiority of models to actual practice, did not venture to give his opinion without having seen them actually tried, and the truth of his doctrines established by practice.

Having described the machines and models used for making his experiments, he observes, that, with regard to power, it is most properly measured by the raising of a weight; or, in other words, if the weight raised is multiplied by the height to which it can be raised in a given time, the product is the measure of the power raising it; and, of consequence, all those powers are equal whose products made by such multiplication are equal: for if a power can raise twice the weight to the same height, or the same weight to twice the height, in the same time that another can, the former power will be double the latter; but if a power can only raise half the weight to double the height or double the weight to half the height, in the same time that another can, the two powers are equal. This, however, must be understood only of a slow and equable motion, without acceleration or retardation; for, if the velocity is either very quickly accelerated or retarded, the vis inertiæ, in our author's opinion, will produce an irregularity.

To compute the effects of water-wheels exactly, it is necessary to know, in the first place, what is the real velocity of the water which impinges on the wheel; 2. The quantity of water expended in a given time; and, 3. How much of the power is lost by the friction of the machinery.

1. With regard to the velocity of the water. Mr. Smeaton determined by experiments with machinery, that with a head of water 15 inches in height, the velocity of the wheel is 8.96 feet in a minute. The area of the head being 105.8 inches; this multiplied by the weight of a cubic inch of water, equal to .579 of an ounce avoirdupois, gives 61.26 ounces for the weight of as much water as is contained in the head upon one inch in depth; and by further calculations derived from the machinery made use of, he computes that 264.7 pounds of water descend in a minute through the space of 15 inches. The power of the water, therefore, to produce mechanical effects in this case, will be 264.7×15, or 3970. From the result of the experiment, however, it appeared that a vast quantity of the power was lost; the effect being only to raise 9.375 pounds to the height of 135 inches: so that the power was to the effect as 3970 to $9.375 \times 135 = 1266$, or as 10 to 3.18.

This, according to our author, must be considered as the greatest single effect of water upon an undershot-wheel, where the water descends from a height of 15 inches; but as the force of the current is not by any means exhausted, we must consider the true proportion betwixt the power and effect to be that betwixt the quantity of water already mentioned, and the sum of all the effects producible from it. This remainder of power, it is plain, must be equal to that of the velocity of the wheel itself multiplied into the weight of the water. In the present experiment, the circumference of the wheel moved with the velocity of 3.123 feet in a second, which answers to a head of 1.82 inches; and this height being multiplied by 264.7, the quantity of water expended in a minute, gives 481 for the power of the water after it has passed the wheel; and hence the true proportion betwixt the power and the effect will be as 3849 to 1266; or as 11 to 4.

As the wheel revolved 86 times in a minute, the velocity of the water must be equal to 86 circumferences of the wheel; which, according to the dimensions of the apparatus used by Mr. Smeaton, was as 86 to 30, or as 20 to 7. The greatest load with which the wheel would move was 9 lb. 6 oz.; and by 12 lb. it was entirely stopped. Whence our author concludes, that the impulse of the water is more than double of what it ought to be according to theory; but this he accounts for by observing, that in his experiment the wheel was placed not in an open river, where the natural current, after it has communicated its impulse to the float, has room on all sides to escape, as the theory supposes, but in a conduit, to which the float being adapted, the water cannot otherwise escape than by moving along with the wheel. It is observable, that a wheel working in this manner, as soon as the water meets the float, receiving a sudden check, it rises up against the float like a wave against a fixed object; insomuch that, when the sheet of water is not a quarter of an inch thick before the float, yet this sheet will act upon the whole surface of a float whose height is three inches; and, consequently, was the float no higher than the thickness of the sheet of water, as the theory also supposes, a great part of the force would have been lost by the water dashing over the float.

Mr. Smeaton next proceeds to give tables of the velocities of wheels with different heights of water; and from the whole deduces the following conclusions: 1. The virtual or effective head being the same, the effect will be nearly as the quantity of water expended. 2. The expense of water being the same, the effect will be nearly

as the height of the virtual, or effective head. 3. The quantity of water expended being the same, the effect is nearly as the square of the velocity. 4. The aperture being the same, the effect will be nearly as the cube of the velocity of the water. Hence, if water passes out of an aperture in the same section, but with different velocities, the expense will be proportional to the velocity; and therefore, if the expense is not proportional to the velocity, the section of the water is not the same. 5. The virtual head, or that from which we are to calculate the power, bears no proportion to the head-water, but when the aperture is larger, or the velocity of the water less, they approach nearer to a coincidence; and consequently, in the large openings of mills and sluices, where great quantities of water are discharged from moderate heads, the head of water, and virtual head determined from the velocity, will nearly agree, which is also confirmed by experience. 6. The most general proportion betwixt the power and effect is that of 10 to 3; the extremes 10 to 3.2, and 10 to 2.8. But it is observable, that where the power is greatest, the second term of the ratio is greatest also: hence we may allow the proportion subsisting in great works to be as three to one. 7. The proportion of velocity between the water and wheel is, in general, about five to two. 8. There is no certain ratio between the load that the wheel will carry at its proper maximum, and what will totally stop it; though the proportions are contained within the limits of 20 to 19, and 20 to 15: but as the effect approaches nearest to the ratio of 20 to 15, or of 4 to 3, when the power is greatest, either by increase of velocity, or quantity of water, this seems to be the most applicable to large works; but as the load that a wheel ought to have, in order to work to the best advantage, can be assigned by knowing the effect that it ought to produce, and the velocity it ought to have in producing it, the exact knowledge of the greatest load it will bear is of the least consequence in practice.

Mr. Smeaton, after having finished his experiments on the undershot-mills, reduced the number of floats, which were originally 24, to 12; which caused a diminution in the effect, by reason that a greater quantity of water escaped between the floats and the floor than before; but on adapting to it a circular sweep of such a length, that one float entered into the curve before the other left it, the effect came so near that of the former, as not to give any hopes of advancing it by increasing the number of floats beyond 24 in this particular wheel.

Our author next proceeds to examine the power of water when acting by its own gravity, in turing an overshot-wheel: "In reasoning without experiment," says he, "one might be led to imagine, that however different the mode of application is, yet that, whenever the same quantity of water descends through the same perpendicular space, the natural effective power would be equal, supposing the machinery free from friction, equally calculated to receive the full effect of the power, and to make the most of it: for, if we suppose the height of a column of water to be 30 inches, and resting upon a base or aperture of one inch square, every cubic inch of water that departs therefrom will acquire the same velocity or momentum from the uniform pressure of 30 cubic inches above it, that one cubic inch let fall from the top will acquire in falling down to the level of the aperture: one would therefore suppose that a cubic inch of water let fall through a space of 30 inches, and there impinging upon another body, would be capable of producing an equal effect by collision, as if the same cubic inch had descended through the same space with a slower motion, and produced its effects gradually. But, however conclusive this reasoning may seem, it will appear in the course of the following deductions, that the effect of the gravity of descending bodies is very different from the effect of the stroke of such as are non-elastic, though generated by an equal mechanical power."

Having made such alterations in his machinery as were necessary for overshot-wheels, our author next gives a table of experiments with the apparatus so altered. In these the head was six inches, and the height of the wheel 24 inches, so that the whole descent was 30 inches; the quantity of water expended in a minute was $96\frac{2}{3}$ pounds; which, multiplied by 30 inches, gives the power = 2900: and, after making the proper calculations, the effect was computed at 1914; whence the ratio of the power to it comes to be nearly as 3 to 2. If, however, we compute the power from the height of the wheel only, the power will be to the effect nearly as 5 to 4.

From another set of experiments the following conclusions were deduced:

1. The effective power of the water must be reckoned upon the whole descent; because it must be raised to that height, in order to be able to produce the same effect a second time. The ratios between the powers so estimated, and the effects at a maximum, differ nearly from 4 to 3, and from 4 to 2. Where the heads of water and quantities of it expended are the least, the proportion is nearly from 4 to 3; but where the heads and quantities are greatest, it comes nearer to that of 4 to 2; so that by a medium of the whole the ratio is nearly as 3 to 2. Hence it appears that the effect of overshot-wheels is nearly double to that of undershot ones: the consequence of which is, that non-elastic bodies, when acting by their impulse or collision, communicate only a part of their original impulse, the remainder being spent in changing their figure in consequence of the stroke. The ultimate conclusion is, that the effects as well as the powers are as the quantities of water and perpendicular heights multiplied together respectively.

2. By increasing the head, it does not appear that the effects are at all augmented in proportion; for by raising it from 3 to 11 inches, the effect was augmented by less than one-seventh of the increase of perpendicular height. Hence it follows, that the higher the wheel is in proportion to the whole descent, the greater will be the effect; because it depends less upon the impulse of the head, and more upon the gravity of the water in the buckets: and if we consider how obliquely the water issuing from the head must strike the buckets, we shall not be at a loss to account for the little advantage that arises from the impulse thereof, and shall immediately see of how little consequence this is to the effect of an overshot-wheel. This, however, as well as other things, must be subject to limitation; for it is necessary that the velocity of the water should be somewhat greater than the wheel, otherwise the latter will not only be retarded by the striking of the buckets against the water, but some of the power will be lost by the dashing of the water over the buckets.

3. To determine the velocity which the circumference of the wheel ought to have, in order to produce the greatest effect, Mr. Smeaton observes, that the more slowly any body descends by the force of gravity, when acting upon any piece of machinery, the more that force will be spent upon it; and consequently the effect will be greater. If a stream of water falls into the bucket of an overshot-wheel, it will be there retained till the wheel discharges it by moving round; and of consequence, the slower the wheel moves, the more water will it receive: so that what is lost in velocity is gained by the greater pressure of water upon the buckets. From the experiments, however, it appears, that when the wheel made about 20 turns in a minute the effect was greatest; when it made only $18\frac{1}{4}$ the motion was irregular; and when loaded so as not to admit its turning 18 times, the wheel was overpowered with the load. When it made 30 turns, the power was diminished by about one-twentieth; and when the number of turns was increased to 40, it was diminished by one-fourth. Hence we see that, in practice, the velocity of the wheel should not be diminished farther than what will procure some solid advantage in point of power; because, cæteris paribus, the buckets must be larger as the motion is slower; and the wheel being more loaded with water, the stress will be proportionably increased upon every part of the work. The best velocity for practice, therefore, will be that when the wheel makes 30 turns in a minute, which is little more than three feet in a second. This velocity is applicable to the highest overshot-wheels as well as the lowest. Experience however determines, that high wheels may deviate farther from this rule before they will lose their power by a given aliquot part of the whole, than low ones can be permitted to do; for a wheel of 24 feet high may move at the rate of six feet per second, while our author has seen one of 33 feet high move very steadily and well with a velocity of little more than two feet. The reason of this superior velocity in the 24-feet wheel, may probably be owing to the small proportion that the head requisite to give the proper velocity to the wheel bears to the whole height.

4. The maximum load for an overshot-wheel is that which reduces the circumference of the wheel to its proper velocity, which is known by dividing the effect it ought to produce in a given time, by the space intended to be described by the circumference of the wheel in the same time: the quotient will be the resistance overcome at the circumference of the wheel, and is equal to the load required, including the friction and resistance of the machinery.

5. The greatest velocity that an overshot-wheel is capable of, depends jointly upon the diameter, or height of the wheel, and the velocity of falling bodies; for it is plain that the velocity of the circumference can never be greater than to describe a semicircumference, while a body let fall from the top describes the diameter, nor even quite so great; as the difference in point of time must always be in favour of that which falls through the diameter. Thus, supposing the diameter of the wheel to be 16 feet and an inch in diameter, a heavy body would fall through this space in one second; but such a wheel could never arrive at this velocity, or make one turn in two seconds, nor could an overshot-wheel ever come near it: because, after it has acquired a certain velocity, great part of the water is prevented from entering the buckets, and part is thrown out again by the centrifugal force; and as these circumstances have a considerable dependance upon the form of the buckets, it is impossible to lay down any general rule for the velocity of this kind of wheels.

6. Though in theory we may suppose a wheel to be made capable of overcoming any resistance whatever, yet as, in practice, it is necessary to make the wheel and buckets of some certain and determinate size, we always find that the wheel will be stopped by such a weight as is equal to the effort of the water in all the buckets of a semicircumference put together. This may be determined from the structure of the buckets themselves; but in practice an overshot-wheel becomes unserviceable long before this time: for when it meets with such an obstacle as diminishes its velocity to a certain, degree its motion becomes irregular; but this never happens till the velocity of the circumference is less than the two feet per second, when the resistance is equable.

7. From the above observations we may easily deduce the force of water upon breast-wheels, &c. But, in general, all kinds of wheels where the water cannot descend through a given space unless the wheel moves with it, are to be considered as overshot-wheels; and those which receive the impulse or shock of the water, whether in an horizontal, oblique, or perpendicular direction, are to be considered as undershots. Hence in a wheel in which the water strikes at a certain point below the surface of the head, and after that descends in the arch of a circle, pressing by its gravity upon the wheel, the effect of such a wheel will be equal to that of an undershot whose head is equal to the difference of level between the surface of the water in the reservoir and the point where it strikes the wheel, added to that of an overshot whose height is equal to the difference of level between the point where it strikes the wheel and the level of the tail-water.

In the 66th volume of the Transactions our author considers some of the causes which have produced disagreements and disputes among mathematicians upon this subject. He observes, that soon after Sir Isaac Newton had given his definition, "that the quantity of motion is the measure of the same, arising from the velocity and quantity of matter conjointly," it was controverted by his contemporary philosophers. They maintaned, that the measure of the quantity of motion should be estimated by taking the quantity of matter and the square of the velocity conjointly. On this subject he remarks, that from equal impelling powers acting for equal intervals of time, equal augmentations of velocity are acquired by given bodies when they are not resisted by a medium. Thus a body descending one second by the force of gravity, passes through a space of 16 feet and an inch; but at the end of that time it has acquired a velocity of 32 feet 2 inches in a second: at the end of 2 seconds it has acquired one that would carry it through 64 feet 4 inches in a second. If, therefore, in consequence of this equal increase of velocity, we define this to be a double quantity of motion generated in a given time in a certain quantity of matter, we come near to sir Isaac's definition: but in trying experiments upon the effects of bodies, it appears, that when a body is put in motion, by whatever cause, the impression it will make upon an uniformly resisting medium, or upon uniformly

yielding substances, will be as the mass of matter of the moving body multiplied by the square of its velocity. The question therefore properly is, whether those terms, the quantity of motion, the momenta, or forces of bodies in motion, are to be esteemed equal, double, or triple, when they have been generated by an equable impulse acting for an equal, double, or triple time? or that it should be measured by the effects being equal, double, or triple, in overcoming resistances before a body in motion can be stopped? For, according to the meaning we put upon these words, the momenta of equal bodies will be as the velocities or squares of the velocities of the moving bodies.

Though by a proper attention to the terms employed, however, we shall find both these doctrines to be true; it is certain that some of the most celebrated writers upon mechanics have fallen into errors by neglecting to attend to the meaning of the terms they make use of. Desaguliers, for instance, after having been at pains to show that the dispute, which in his time had subsisted for 50 years, was a dispute merely about words, tell us, that both opinions may be easily reconciled in the following case, viz. that the wheel of an undershot water-mill is capable of doing quadruple work when the velocity of the water is doubled, instead of double work only: "For," says he, "the adjutage being the same, we find, that as the water's velocity is double, there are twice the number of particles that issue out, and therefore the ladle-board is struck by twice the matter; which matter moving with twice the velocity that it had in the first case, the whole effect must be quadruple, though the instantaneous stroke of each particle is increased only in a simple proportion of the velocity." In another place the same author tells us, that though "the knowledge of the foregoing particulars is absolutely necessary for setting an undershot-wheel to work, yet the advantage to be reaped from it would still be guess-work, and we should be at a loss to find out the utmost that it could perform, had it not been for an ingenious proposition of that excellent mechanic, M. Parent, of the royal academy of sciences, who has showed, that an undershot-wheel can do the most work when its velocity is equal to the third part of that of the water; because then two-thirds of the water are employed in driving the wheel, with a force proportionable to the square of the velocity. By multiplying the surface of the adjutage or opening by the height of the water, we shall have the column of water that moves the wheel. The wheel thus moved will sustain on the opposite side only four-ninths of that weight which will keep it in equilibrio; but what it can move with the velocity it has, is only one-third of the equilibrium." This conclusion is likewise adopted by Mr. Maclaurin.

Mr. Smeaton, in the year 1759, instituted another set of experiments; the immediate object of which was, to determine what proportion or quantity of mechanical power is expended in giving the same body different degrees of velocity. Having constructed a proper apparatus for the purpose, and with it made a number of experiments, he concludes, "that time, properly speaking, has nothing to do with the production of mechanical effects, otherwise than as by equally flowing it becomes a common measure; so that, whatever mechanical effect is found to be produced in a given time, the uniform continuance of the action of the same mechanical power will, in a double time, produce twice that effect. A mechanical power therefore, properly speaking, is treasured by the whole of its mechanical effect produced, whether that effect be produced in a greater or less time: thus, having treasured up 1000 tons of water, which I can let out upon the overshot-wheel of a mill, and desdending through a perpendicular of 20 feet; this power, applied in a proper manner, will grind a certain quantity of corn in an hour: but, suppossing the mill to be capable of receiving a greater impulse with as great advantage as a less; then, if the corn is let out twice as fast, the same quantity of corn will be ground in half an hour, the whole of the water being likewise expended in that time. What time has therefore to do in the case is this: Let the rate of doing the business, or producing the effect, be what it will; if this rate is uniform, when I have found by experiment what is done in a given time, then, proceeding at the same rate, twice the effect will be produced in twice the time; on supposition that I have a supply of mechanic power to go on with. Thus, 1000 tuns of water descending through 20 feet perpendicular, being, as has been shown, a given mechanic power, let it be expended at what rate it will; if, when this is expended, we are to wait another hour till an equal quantity can be procured, then we can only expend 12 such quantities in 24 hours. But if, while the thousand tuns of water are expending in one hour, the same quantity is renewed, we can then expend 24 such in the 24 hours, or go on without intermission. The product or effect will then be in proportion to time, which is the common measure; but the quantity of mechanic power arising from the flow of the two rivers, compared by taking an equal portion of time, is double in the one to the other; though each has a mill that, when going, will grind an equal quantity of corn in an hour."

The following is a description of a corn-mill of the most common sort. See Plate LXXXVIII. Mills.

AB (fig. 1) is the water-wheel, which is generally from 18 to 24 feet in diameter, reckoned from the outermost edge of any float-board at A, to that of the opposite one at B. The water striking on the floats of this wheel drives it round, and gives motion to the mill. The wheel is fixed upon a very strong axis or shaft, C, one end of which rests on D, and the other on E, within the mill-house.

On this shaft, or axis, and within the mill-house, is a wheel F, about eight or nine feet in diameter, having cogs all round, which work in the upright staves, or rounds, of a trundle G. This trundle is fixed upon a strong iron axis, called the spindle, the lower end of which turns in a brass foot fixed at H, in a horizontal beam H, called the bridge-tree; and the upper end of the spindle turns in a wooden bush fixed into the nether mill-stone, which lies upon beams in the floor I. The top of the spindle above the bush is square, and goes into a square hole in a strong iron cross, *abcd* (fig. 2), called the rynd; under which, and close to the bush, is a round piece of thick leather upon the spindle, which it turns round at the same time as it does the rynd.

The rynd is let into grooves in the under surface of the running mill-stone K, and so turns it round in the same time that the trundle G is turned round by the cog-wheel F. This mill-stone has a large hole quite through

its middle, called the eye of the stone, through which the middle part of the rynd and upper end of the spindle may be seen; whilst the four ends of the rynd lie below the stone in their grooves.

One end of the bridge-tree, which supports the spindle, rests upon the wall, whilst the other is let into a beam, called the brayer, LM.

The brayer rests in a mortice at L; and the other end M hangs by a strong iron rod N, which goes through the floor I, and has a screw-nut on its top at O; by the turning of which nut, the end M of the brayer is raised or depressed at pleasure; and consequently the bridge-tree and the upper mill-stone. By this means the upper mill-stone may be set as close to the under one, or raised as high from it, as the miller pleases.

The nearer the mill-stones are to each other, the finer the corn is ground; and the more remote from one another, the coarser.

The upper mill-stone is inclosed in a round box, which does not touch it any where, and is about an inch distant from its edge all round. On the top of this box stands a frame for holding the hopper P, to which is hung the shoe Q, by two lines fastened to the hinder part of it, fixed upon hooks in the hopper, and by one end of the string R fastened to the fore part of it; the other end being twisted round the pin S. As the pin is turned one way, the string draws up the shoe closer to the hopper, and so lessens the aperture between them; and as the pin is turned the other way, its lets down the shoe, and enlarges the aperture.

If the shoe is drawn up quite to the hopper, no corn can fall from the hopper into the mill: if it is let down a little, some will fall; and the quantity will be more or less, according as the shoe is more or less let down; for the hopper is open at bottom, and there is a hole in the bottom of the shoe, not directly under the bottom of the hopper, but nearer to the lowest end of the shoe, over the middle ere of the mill-stone.

There is a square hole in the top of the spindle, in which is put the feeder F (fig. 2); this feeder, as the spindle turns round, jogs the shoe three times in each revolution, and so causes the corn to run constantly down from the hopper through the shoe into the eye of the mill-stone, where it falls upon the top of the rynd; and is, by the motion of the rynd, and the leather under it, thrown below the upper stone, and ground between it and the lower one. The violent motion of the stone creates a centrifugal force in the corn going round with it, by which means it gets farther and farther from the centre, as in a spiral, in every revolution, until it is quite thrown out; and being then ground, it falls through a spout, called the mill-eye, into a trough placed to receive it.

When the mill is fed too fast the corn bears up the stone, and is ground too coarse; and, besides, it clogs the mill, so as to make it go too slow. When the mill is too slowly fed, it goes too fast; and the stones, by their attrition, are apt to strike fire. Both these inconveniences are avoided by turning the pin S backward or forward, which draws up or lets down the shoe; and thus regulates the feeding, as the miller sees convenient.

The heavier the running mill-stone is, and the greater the quantity of water that falls upon the wheel, the faster will the mill bear to be fed, and consequently it will grind the more: and, on the contrary, the lighter the stone, and the less the quantity of water, so much the slower must the feeding be. But when the stone is considerably worn, and become light, the mill must be fed slowly at any rate; otherwise the stone will be too much borne up by the corn under it, which will make the meal coarse.

The quantity of power sufficient to turn a heavy mill-stone, is but very little more than what is necessary to turn a light one; for as it is supported upon the spindle by the bridge-tree, and the end of the spindle that turns in the brass foot therein being but small, the difference arising from the weight is but very inconsiderable in its action against the power or force of the water; and, besides, a heavy stone has the same advantage as a heavy fly, namely, that it regulates the motion much better than a light one.

The centrifugal force carrying the corn towards the circumference, it is natural it should be crushed, when it comes to a place where the interval between the two mill-stones is less than its thickness; yet the upper mill stone being supported on a point which it can never quit, it does not so clearly appear why it should produce a greater effect when it is heavy than when it is light; since, if it were equally distant from the nether mill-stone, it could only be capable of a limited impression. But as experience proves that this is really the case, it is necessary to discover the cause. The spindle of the mill-stone being supported by a horizontal piece of timber, about nine or ten feet long, resting only on both its ends, by the elasticity of this piece, the upper mill-stone is allowed a vertical motion, playing up and down; by which movement, the heavier the stones are, the more forcibly is the corn wedged in between them.

In order to cut and grind the corn, both the upper and under mill-stones have channels or furrows cut into them, proceeding obliquely from the centre to the circumference. And these furrows are cut perpendicularly on one side, and obliquely on the other, which gives each furrow a sharp edge; and in the two stones they come against one another, like the edges of a pair of scissars; and so cut the corn, to make it grind the easier, when it falls upon the places between the furrows. These are cut the same way in both stones, when they lie upon their backs, which makes them run crossways to each other when the upper stone is inverted, by turning its furrowed surface towards that of the lower; for if the furrows of both stones lay the same way, a great deal of the corn would be driven onward in the lower furrows, and so come out from between the stones, without being either cut or bruised.

The grinding surface of the under stone is a little convex from the edge to the centre, and that of the upper stone a little concave; so that they are farthest from one another in the middle, and approach gradually nearer towards the edges. By this means the corn, at its first entrance between the stones, is only bruised; but as it goes farther on towards the circumference or edge, it is cut smaller and smaller; and, at last, finely ground, just before it comes out from between them.

When the furrows become blunt and shallow by wearing, the running-stone must be taken up, and both stones new drest with a chisel and hammer; and every time the

stone is taken up there must be some tallow put round the spindle upon the bush, which will soon be melted by the heat of the spindle acquires from its turning and rubbing against the bush, and so will get in betwixt them; otherwise the bush would take fire in a very little time.

The bush must embrace the spindle quite close, to prevent any shake in the motion, which would make some parts of the stones grate and fire against each other; whilst the other parts of them would be too far asunder, and by that means spoil the meal.

Whenever the spindle wears the bush, so as to begin to shake in it, the stone must be taken up, and a chisel driven into several parts of the bush; and when it is taken out, wooden wedges must be forced into the holes; by which means the bush will be made to embrace the spindle again, close all round. In doing this, great care must be taken to drive equal wedges into the bush on opposite sides of the spindle; otherwise it will be thrown out of the perpendicular, and so hinder the upper stone from being set parallel to the under one, which is absolutely necessary for making good work. When any accident of this kind happens, the perpendicular position of the spindle must be restored, by adjusting the bridge-tree with proper wedges put between it and the brayer.

It often happens that the rynd is a little wrenched in laying down the upper stone upon it, or is made to sink a little lower on one side of the spindle than on the other; and this will cause one edge of the upper stone to drag all round upon the other, while the opposite edge will not touch. But this is easily set to rights, by raising the stone a little with the lever, and putting bits of paper, cards, or thin chips, between the rynd and the stone.

A less quantity of water will turn an overshot-mill (where the wheel has buckets instead of float-boards) than a breast-mill, where the fall of water seldom exceeds half the height of the wheel; so that where there is but a small quantity of water, and a fall great enough for the wheel to lie under it, the bucket, or overshot, wheel, is always used: but where there is a large body of water with a little fall, the breast, or float-board, wheel must be used. Where the water runs only upon a small declivity, it can act but slowly upon the under part of the wheel; in which case the motion of the wheel will be slow: and therefore the floats ought to be very long, though not high, that a large body of water may act upon them; so that what is wanting in velocity may be made up in power; and then the cog-wheel may have a greater number of cogs, in proportion to the rounds in the trundle, in order to give the mill-stone a sufficient degree of velocity.

It was the opinion of Smeaton, that the powers necessary to produce the same effect on an undershot-wheel, a breast-wheel, and an overshot-wheel, must be to each other as the numbers 2.4, 1.75, and 1.

Practical rules for the construction of mills.—1. Measure the perpendicular height of the fall of water, in feet, above that part of the wheel on which the water begins to act, and call that the height of the fall.

2. Multiply this constant number 64.2882 by the height of the fall in feet, and the square root of the product will be the velocity of the water at the bottom of the fall, or the number of feet that the water there moves per second.

3. Divide the velocity of the water by three, and the quotient will be the velocity of the float-boards of the wheel, or the number of feet they must each go through in a second, when the water acts upon them so as to have the greatest power to turn the mill.

4. Divide the circumference of the wheel in feet by the velocity of its floats in feet per second, and the quotient will be the number of seconds in which the wheel turns round.

5. By this last number of seconds divide 60, and the quotient will be the number of turns of the wheel in a minute.

6. Divide 120 (the number of revolutions a mill-stone four feet and a half diameter ought to have in a minute) by the number of turns of the wheel in a minute, and the quotient will be the number of turns the mill-stone ought to have for one turn of the wheel.

7. Then, as the number of turns of the wheel in a minute, is to the number of turns of the mill-stone in a minute, so must the number of staves in the trundle, be to the number of cogs in the wheel, in the nearest whole numbers that can be found.

By these rules the following table is calculated to a water-wheel 18 feet diameter, which may be a good size in general.

THE MILL-WRIGHT'S TABLE.

Height of the fall of water.	Velocity of the fall of water per second.		Velocity of the wheel per second.		Revolutions of the wheel per minute.		Revolutions of the mill-stone for one of the wheel.		Cogs in the wheel, and staves in the trundle.		Revolutions of the mill-stone per minute, by these staves and cogs.	
Feet.	Feet.	100 parts of a foot.	Feet.	100 parts of a foot.	Revolutions.	100 parts of a rev.	Revolutions.	100 parts of a rev.	Cogs.	Staves.	Revolutions.	100 parts of a rev.
1	8.02		2.67		2.83		42.40		254	6	119.84	
2	11.34		3.78		4.00		30.00		210	7	120.00	
3	13.89		4.63		4.91		24.44		196	8	120.28	
4	16.04		5.35		5.67		21.16		190	9	119.74	
5	17.93		5.98		6.34		18.92		170	9	119.68	
6	19.64		6.55		6.94		17.28		156	9	120.20	
7	21.21		7.07		7.50		16.00		144	9	120.00	
8	22.68		7.56		8.02		14.96		134	9	119.34	
9	24.05		8.02		8.51		14.10		140	10	119.14	
10	25.35		8.45		8.97		13.38		134	10	120.18	
11	26.59		8.86		9.40		12.76		128	10	120.32	
12	27.77		9.26		9.82		12.22		122	10	119.80	
13	28.91		9.64		10.22		11.74		118	10	120.36	
14	30.00		10.00		10.60		11.32		112	10	118.72	
15	31.05		10.35		10.99		10.98		110	10	120.96	
16	32.07		10.09		11.34		10.58		106	10	120.20	
17	33.06		11.02		11.70		10.26		102	10	119.34	
18	34.02		11.34		12.02		9.98		100	10	120.20	
19	34.95		11.65		12.37		9.70		98	10	121.22	
20	35.86		11.95		12.68		9.46		94	10	119.18	
1	2		3		4		5		6		7	

To construct a mill by this table, find the height of the fall of water in the first column, and against that height, in the sixth column, you have the number of cogs in the wheel, and staves in the trundle, for causing the mill-stone, four feet six inches diameter, to make about 120 revolutions in a minute, as near as possible, when the wheel goes with one-third part of the velocity of the water. And it appears by the 7th column, that the number of cogs in the wheel, and staves in the trundle, are so near the truth for the required purpose, that the least number of revolutions of the mill-stone in a minute is 118, and the greatest number never exceeds 121; which is according to the speed of some of the best mills.

One of the most usuel communications of motion in machinery, is by toothed wheels acting on each other. It is of the greatest consequence to have the teeth so formed, that the pressure by which one of them urges the other round its axis is constantly the same. This is by no means the case when the common construction of a spur-wheel, acting in the cylindrical staves of a lantern, or trundle, is used. The ends of teeth should never be formed of parts of circles, but of a particular curve, called the epicycloid, which is formed by moving the circle, called the generating circle, round the circumference of another circle, while it turns also round its own centre; then any point will describe an epicycloid.

Emerson observes, that the teeth of wheels ought not to act upon each other before they arrive at the line which joins their centres; and though the inner or under sides of the the teeth may be of any form, yet it is better to make both sides alike, which will serve to make the wheel turn backwards. The more teeth that work together the better; at least one tooth should always begin before the other has done working. The teeth ought to be so disposed as not to trouble or hinder one another before they begin to work.

If the cogs of a wheel and rounds of a trundle could be put in as exactly as the teeth are cut in the wheels and pinions of a clock, then the trundle might divide the wheel exactly, that is to say, the trundle might make a given number of revolutions for one of the wheel, without a fraction. But as any exact number is not necessary in mill-work, and the cogs and rounds cannot be set in so truly as to make all the intervals between them equal, a skilful mill-wright will always give the wheel what he calls a hunting-cog; that is, one more than what will answer to an exact division of the wheel by the trundle. And then as every cog comes to the trundle, it will take the next staff, or round, behind the one which it took in the former revolution; and by that means will wear all the parts of the cogs and rounds which work upon one another equally, and to equal distances from one another, in a little time. See Flour-mill.

Mills, Bark, like most other mills, are worked sometimes by means of horses, at others by water, and at others by wind. One of the best mills we have seen described for these purposes is that invented by Mr. Bagnall, of Worsley, in Lancashire: this machine will serve not only

to chop bark, to grind, to riddle, and pound it, but to beam, or work green hides out of the mastering, or drench, and make them ready for the ouse, or bark-liquor; to beam sheepskins and other skins for the skinner's use; and to scour and take off the bloom from tanned leather when in the currying state. The nature and connection of the different parts of this contrivance may be understood from the figures and following description:

Fig. 3 is a horizontal plan of the mill. Fig. 4, a longitudinal section of it. Fig. 5, a transverse section of it.

A, the water-wheel, by which the whole machinery is worked.

B, the shafts.

C, the pit-wheel, which is fixed on the water-wheel shaft B, and turns the upright shaft E, by the wheel F, and works the cutters and hammer by tapets.

D, the spur and bevil-wheel at the top of the upright shafts.

E, the upright shaft.

F, the crown-wheel, which works in the pit-wheel C.

G, the spur-nut to turn the stones I.

P, the beam, with knives or cutters fixed at the end to chop or cut the bark; which bark is to be put upon the cutters or grating *i*, on which the beam is to fall.

Q, the tryal that receives the bark from the cutters *i*, and conveys it into the hopper H, by which it descends through the shoe J to the stones I, where it is ground.

K, the spout, which receives the bark from the stones, and conveys it into the tryal L; which tryal is wired to sift or dress the bark, as it descends from the stones I.

M, the trough to receive the bark that passes through the tryal L.

R, the hammer, to crush or bruise the bark that falls into the dish S, which said dish is on the incline, so that the hammer keeps forcing it out of the lower side of the said dish when bruised.

k, a trough to receive the dust and moss that passes through the tryal Q.

T, the bevil-wheel, that works in the wheel D, which works the beam-knife by a crank V, at the end of the shaft *u*.

W, the penetrating rod, which leads from the crank V to the start *x*.

x, the start, which has several holes in it to lengthen or shorten the stroke of the beam-knife.

y, the shaft, to which the slide rods *h*, *h*, are fixed by the starts *n*, *n*.

h, the slide-rod, on which the knife *f* is fixed; which knife is to work the hides, &c. On the knife are two springs *a*, *a*, to let it have a little play as it makes its stroke backwards and forwards, so that it may not scratch or damage the hides, &c.

z, is a catch in a slide-rod *h*, which catches on the arch-head *e*; and the said arch-head conveys the knife back without touching the hide, and then falls back to receive the catch again.

l, the roller to take up the slide-rod *h*, while the hides are shifting on the beam *b*, by pulling at the handle *m*.

b, the beam to work the hides, &c. on. Each beam has four wheels *p*, *p*, working in a trough-road *g*, *g*, and removed by the levers *c*, *c*. When the knife has worked the hide, &c. sufficiently in one part, the beam is then shifted by the lever *c* as far as is wanted.

d, a press, at the upper end of the beam, to hold the hide fast on the beam while working.

e, an arch-head, on which the slide-rod *h* catches.

f, the knife fixed on the slide-rod *h*, to work the hides, &c.

i, cutters, or grating, to receive the bark for chopping.

The beam P, with knives or cutters, may either be worked by tapers, as described, or by the bevil-wheel T, with a crank, as V, to cut the same as shears.

The knife *f* is fixed at the bottom of the start, which is fixed on the slide-rod *h*; the bottom of the start is split open to admit the knife, the width of one foot; the knife should have a gudgeon at each end, to fix in the open part of the start; and the two springs *a*, *a*, prevent the knife from giving too much way when working; the knife should be one foot long, and four or five inches broad.

The arch-head *e* will shift nearer to, or further from, the beam *h*; and will be fixed so as to carry the knife back as far as is wanted, or it may be taken away till wanted.

The roller *l* is taken up by pulling at the handle *m*, which takes up the slide-rod so high as to give head-room under the beam-knife. The handle may be hung upon a hook for that purpose. The slide-rod will keep running upon the roller all the time the hide is shifting; and when the hide is fixed the knife is put on the beam again by letting it down by the handle *m*. There may be two or more knives at work on one beam at the same time, by having different slide-rods. There should be two beams, so that the workmen could be shifting one hide, &c. while the other was working. The beam must be flat, and a little on the incline. As to the breadth it does not matter; the broader it is the less shifting of the hides will be wanted, as the lever *c* will shift them as far as the width of the hide, if required. Mr. Bagnall has formed a kind of press *d*, to let down, by a lever, to hold the hide fast on each side of the knife, if required, so that it will suffer the knife to make its back stroke without pulling the hide up as it comes back. The slide-rod may be weighted, to cause the knife to lay stress on the hide, &c. according to the kind and condition of the goods to be worked.

Hides and skins for the skinner's use are worked in the same way as for the tanners.

Scouring of tanned leather for the currier's use will be done on the beam, the same as working green hides. It is only taking the knife away, and fixing a stone in the same manner as the knife by the said joint, and to have a brush fixed to go either before or after the stone. The leather will be better secured this way than by hand, and much sooner.

The whole machinery may be worked by water, wind, steam, or any other power. And that part of the machinery which relates to the beaming part of the hides may be fixed to any horse bark-mill, or may be worked by a horse, or other power, separately. See Gregory's valuable work on Mechanics, to which we have been indebted for this part of the present article and some others, particularly the table of specific gravities.

The following is a description of Mr. Terry's improved mill for grinding hard substances: Fig. 6, A, is the hopper; B, a spiral wire, in the form of a reversed cone, to regulate the delivery of the articles to be ground; C, an inclined iron plate, hung upon a pin on its higher end: the lower end rests on the grooved axis D, and agitates the wire B; D is the grinding cylinder, which acts against the channelled iron plate E; F, a screw on the side of the mill, by means of which the iron plate E is brought nearer to, or removed farther from, the axis D, according as the article is wanted finer or coarser; G, the handle by which motion is given to the axis; H, the tube whence the articles, when ground, are received.

Mill *for grinding colours.* A machine of this kind was invented a few years ago by Mr. Rawlinson, for which he was presented with the gold medal by the society for the encouragement of arts, manufactures, &c. the description of which is as follows:

A, fig. 7, is the roller, or cylinder, made of marble; B is the concave muller, covering one-third of the roller of the same marble, and is fixed in a wooden frame *b*, which is hung to the frame E, at *ii*. C is a piece of iron about an inch broad, to keep the muller steady, and is fixed to the frame with a joint at *f*. The small binding screw, with the fly-nut that passes through the centre of the iron plate at *c*, is for the purpose of laying more pressure on the muller, if required, and to keep it more steady. D is a taker-off, made of a clock-spring, about half an inch broad, and fixed to a similar frame-saw, in an iron frame K, in an inclined position to the roller, and turning on pivots at *dd*. G is a slide-board, to draw out occasionally, to clean, and to sustain the plate H, to catch the colour on as it falls from the taker-off. F is a drawer, for the purpose of containing curriers' shavings, which are the best things for cleaning paint-mills.

We shall now add an account of an improved mill for grinding indigo, or other dry colours. L, fig. 8, represents a mortar made of hard marble, or hard stone; M, a muller, nearly in the form of a pear, in the upper part of which an iron axis is firmly fixed; which axis, at the parts NN, turns in grooves or slits, cut in two pieces of oak, projecting horizontally from a wall; and when the axis is at work, it is secured in the grooves by iron pins, OO. P, the handle, which forms part of the axis, and by which the grinder is worked. Q, the wall, in which the oak pieces, NN, are fixed. R, a weight, which may occasionally be added, if more power is wanted. Fig. 9 shows the muller, with its axis, separate from the other machinery; its bottom should be made to fit the mortar. S is a groove cut through the stone. The indigo, &c. to be ground, is thrown above the muller into the mortar; on turning the handle the lumps fall into the grove cut through the muller, and are thence drawn under its action, and driven to the outer edge within the mortar, from whence the coarser particles again fall into the groove of the muller, and are again ground under it. A wooden cover, in two halves, with a hole for the axis, is usually placed upon the mortar, during the operation, to prevent loss of colour, or bad effect to the operator.

Mill, Foot, is a mill for grinding corn or any other substance, moved by the pressure of the feet of men or animals. In some foot-mills a horse or an ox is fixed to a stall upon a floor above a vertical wheel; and a hole is made in the floor in the place where the hind feet of the animal should stand; thus admitting those feet to press upon the rim of a wheel, and cause the wheel to turn upon its axle, and give motion to the whole mill. But in this kind of machine the animal will be obliged very unnaturally to move his hind feet while his fore feet will be at rest; and further, the motive force being applied near the vertex of the wheel will act but with little advantage; and the work done will be comparatively trifling.

Hand-Mill, or *horse-mill*, is that worked by the hand, or by horses, &c. There is a long beam or lever for moving it, so attached that it may receive many men or horses, to drive several mills at once. There is the cog-wheel, placed horizontally, with pins fixed, not on its plane, but on the outside, at the circumference of its joints. There are also the trundle-head, the support, the iron axis, and the drum where the mill-stones are inclosed.

MILLENARIANS, or Chiliasts, a name given to those who, in the primitive ages, believed that the saints will one day reign on earth with Jesus Christ a thousand years.

MILLEPES. See Oniscus.

MILLEPORA. See Madrepore, Zoophites, and Plate XCI. Nat. Hist. figs. 266, 267.

MILLERIA, a genus of the syngenesia polygamia necessaria class of plants, the compound flower of which is radiated; there is scarcely any visible receptacle of the seeds, which are single after each particular flower, and have no pappus or down. There are three species.

MILLET. See Milium, and Panicum.

Millet-grass. See Milium.

MILLING. See Fulling.

MIMOSA, the *sensitive plant*, a genus of the polygamia order, in the monœcia class of plants, and in the natural method ranking under the 33d order, lomentaceæ. The hermaphrodite calyx is quinquedentate; the corolla quinquefid; there are five or more stamina, one pistil, and a legumen; the male calyx is quinquedentate; the corolla quinquefid, with five, ten, or more stamina.

The name mimosa signifies "mimic;" and is given to this genus on account of the sensibility of the leaves, which, by their motion, mimic or imitate the motion of animals. This genus comprises 85 different species, all natives of warm climates. Of the sorts cultivated here in our stoves, &c. some are of the shrub and tree kind, and two or three are herbaceous perennials and annuals. The sensitive kinds are exceedingly curious plants in the very singular circumstance of their leaves receding rapidly from the touch, and running up close together; and in some sorts the footstalks and all are affected, so as instantly to fall downward as if fastened by hinges, which last are called humble sensitives. They have all winged leaves, each wing consisting of many small pinnæ. The following are the most remarkable:

1. The sensitiva, or common sensitive humble plant, rises with an under-shrubby prickly stem, branching six or eight feet high, armed with crooked spines; conjugated, pinnated leaves, with bijugated partial lobes or wings, having the inner ones the least, each leaf on a long footstalk; and at the sides and ends of the branches many purple flowers in roundish heads; succeeded by broad, flat, jointed pods, in radiated clusters. This is somewhat of the humble sensitive kind; the leaves, footstalks and

all, receding from the touch, though not with such facility as in some of the following sorts.

2. The pudica, or bashful humble plant, rises with an under-shrubby, delineated. prickly stem, branching two or three feet round, armed with hairy spines. This is truly of the humble sensitive kind; for by the least touch the leaves instantly recede, contract, close, and, together with the footstalk, quickly decline downward, as if ashamed at the approach of the hand.

3. The pernambuca, or pernambuca slothful mimosa, recedes very slowly from the touch, only contracting its pinnæ a little when smartly touched: hence the name slothful mimosa.

4. The asperata, or Panama sensitive plant, seldom rises above three feet in height; but its slender branches extend considerably on the neighbouring bushes. It is armed with crooked sharp spines, so thickly set on the trunk, branches, and leaves, that there is no touching it with safety. But the plant has a beautiful appearance, the flowers are yellow and globular, growing at the extremity of the branches. The pods are hairy, brown, and jointed; each containing a small, flat, and brown seed. The leaves are numerous, small, and winged: next to those of the mimosa pudica they are the most irritable; contracting with the least touch, and remaining so for several minutes after. This species would form a good hedge or fence round a garden.

5. The punctata, or punctated sensitive mimosa, rises with a shrubby, upright, taper, spotted, unarmed stem, branching erectly five or six feet high; bipinnated leaves, of four or five pair of long winged folioles, having each about 20 pair of pinnæ; and at the axillas and termination of the branches oblong spikes of yellowish decandruous flowers, the inferior ones castrated; succeeded above by oblong seed-pods. This sort, though naturally shrubby and perennial in its native soil, yet in this country sometimes decays in winter. It is only sensitive in the foliola, but quick in the motion.

6. The viva, lively mimosa, or smallest sensitive weed, has many creeping roots, and spreads itself so as to cover large spots of ground. It rises at most to two inches, and has winged leaves, with numerous small pinnæ. The flower is globular, of a blueish colour, and grows in clusters from the axillæ: these are followed by little, short, hairy pods, containing smooth shining seeds. This is the most sensible of all the mimosas, the pudica not excepted. By running a stick over the plant, a person may write his name, and it will remain visible for ten minutes.

7. The quadrivalvis humble mimosa, has herbaceous, slender, quadrangular, prickly stems, branching and spreading all around, armed with recurved spines: bipinnated leaves of two or three pair of winged lobes, having each many pinnæ; and at the axillas globular heads of purple flowers, succeeded by quadrivalvular pods. This is of the humble sensitive kind, both leaves and footstalks receding from the touch.

8. The plena, annual, or double-flowered sensitive mimosa, rises with an herbaceous, erect. round, unarmed stem, closely branching and spreading every way, three or four feet high; bipinnated leaves of four or five pair of winged lobes, of many pairs of pinnæ; and at the axillas and termination of the branches, spikes of yellow pentandrous flowers, the lower ones double, succeeded by short broad pods. This annual is only sensitive in the foliola, but extremely sensible of the touch or air.

9. The cornigera, or horned Mexican mimosa, commonly called great horned acacia, has a shrubby, upright, deformed stem, branching irregularly, armed with very large horn-like white spines, by pairs, connected at the base; bipinnated leaves thinly placed; and flowers growing in spikes. This species is esteemed a curiosity for the oddity of its large spines, resembling the horns of animals, and which are often variously wreathed, twisted, and contorted.

10. The farnesiana, or fragrant acacia, grows in woodlands and waste lands in most parts of Jamaica; rising to 25 or 30 feet, with suitable thickness. Formerly the flowers of this tree were used as an ingredient in the theriaca andromachi of the old dispensatories. This tree is sometimes planted for a hedge or fence round inclosures; and the timber, though small, is useful in rural economy.

11. The arborea, or wild tamarind-tree, is common in all the woodlands, and especially near where settlements have been made, in Jamaica. It rises to a considerable height, and is proportionably thick. The timber is excellent, and serves many purposes in rural economy: it is of the colour of cedar, pretty hard, and takes a good polish. The leaves are numerous; the flowers globular and white. The pods are about a foot in length, of a fine scarlet colour, when they are ripe they open and become twisted. The seeds then appear.

12. The latifolia, shag-bark, or white wild tamarind. This excellent timber-tree is very common in Jamaica, and rises to a moderate height and good thickness. The trunk is rough and scaly: the leaves are numerous, of a rhomboidal figure, and yellowish cast. The flower-spikes are from the axillæ; their colour is yellow. The seed-vessels are flat, jointed, and twisted. The seeds are of the bigness of a vetch, white, and finely streaked with blue.

13. The lebeck, or ebony-tree. This is a native of the East Indies, but raised from seeds in Jamaica and St. Vincent's.

14. The scandens, cacoons, or mafootoo wyth, is frequent in all the upland valleys and woodlands on the north side of Jamaica. It climbs up the tallest trees, and spreads itself in every direction by means of its cirrhi, or claspers, so as to form a complete arbour, and to cover the space of an English acre from one root. This circumstance has a bad effect on the trees or bushes so shaded; light, air, and rain, (so necessary for all plants,) being shut out, the leaves drop off, the tree gradually rots, and the limbs fall down by the weight of this parasite.

The roots of this plant run superficially under the ground or herbage. The trunk is seldom thicker than a man's thigh; and sends off many branches, with numerous shining green leaves, each of which terminates in a tendril or clasper, that serves to fasten it to trees or bushes. The flower-spikes are from the axillæ: they are slender, and the florets on them small and numerous. The pod is perhaps the largest and longest in the world; being sometimes 8 or 9 feet in length, five inches broad, jointed, and containing 10 or 15 seeds. These seeds are brown, shining, flattened, and very hard, and called cacoons.

They are the same as mentioned in the Philosophical Transactions, No. 222, page 298, by sir Hans Sloane, as being thrown ashore on the Hebrides and Orkneys.

This bean, after being long soaked in water, is boiled and eaten by some negroes; but, in general, there seems to be no other use made of it than as a sort of snuff-box.

15. The catechu, according to Mr. Ker (Med. Obs. and Inquir. vol. v. p. 151, &c.), grows only to 12 feet in height, and to one foot in diameter; it is covered with a thick, rough, brown bark, and towards the top divides into many close branches: the leaves are bipinnated, or doubly winged, and are placed alternately upon the younger branches: the partial pinnæ are nearly two inches long, and are commonly from 15 to 30 pair, having full glands inserted between the pinnæ: each wing is usually furnished with about 40 pair of pinnulæ, or linear lobes, beset with short hairs: the spines are short. From this tree, which grows plentifully on the mountainous parts of Indostan, where it flowers in June, is produced the officinal drug long known in Europe by the name of terra japonica.

16. The nilotica, or true Egyptian acacia, rises to a greater height than the preceding. The fruit is a long pod, resembling that of the lupin, and contains many flattish brown seeds. It is a native of Arabia and Egypt, and flowers in July. Although the mimosa nilotica grows in great abundance over the vast extent of Africa, yet gum arabic is produced chiefly by those trees which are situated near the equatorial regions; and we are told that in Lower Egypt the solar heat is never sufficiently intense for this purpose. The gum exudes in a liquid state from the bark of the trunk and branches of the tree, in a similar manner to the gum which is often produced upon the cherry-trees, &c. in this country; and by exposure to the air it soon acquires solidity and hardness. In Senegal the gum begins to flow when the tree first opens its flowers; and continues during the rainy season till the month of December, when it is collected for the first time. Another collection of the gum is made in the month of March, from incisions in the bark, which the extreme dryness of the air at that time is said to render necessary. Gum arabic is now usually imported into England from Barbary, in large casks or hogsheads. The common appearance of this gum is well known; and the various figures which it assumes seem to depend upon a variety of accidental circumstances attending its transudation and concretion. Gum arabic of a pale yellowish colour is most esteemed; on the contrary, those pieces which are large, rough, of a roundish figure, and of a brownish or reddish hue, are found to be less pure, and are said to be produced from a different species of mimosa; but the Arabian and Egyptian gum is commonly intermixed with pieces of this kind, similar to that which comes from the coast of Africa near the river Senegal.

Gum arabic does not admit of solution by spirit or oil; but in twice its quantity of water it dissolves into a mucilaginous fluid, of the consistence of a thick syrup; and in this state answers many useful pharmaceutical purposes, by rendering oily, resinous, and pinguious substances, miscible with water. The glutinous quality of gum arabic is preferred to most other gums and mucilaginous substances, as a demulcent in coughs, hoarsenesses, and other catarrhal affections, in order to obtund irritating acrimonious humours, and to supply the loss of abraded mucus. It has been very generally employed in cases of ardor urinæ and strangury; but it is the opinion of Dr. Cullen, "that even this mucilage, as an internal demulcent, can be of no service beyond the alimentary canal."

17. The senegal is a native of Guinea, and was some time ago introduced into Jamaica. The flowers are globular, yellow and fragrant. The pods are brown, and of the size of a goose-quill. The tree, on being wounded, exudes gum arabic, though in less quantity, and less transparent, than that of the shops, which is obtained from the nilotica above described.

There are above 40 other species characterised in the Systema Vegetabilium.

MIMULUS, *monkey flower*, a genus of the didynamia angiospermia class of plants, with double stigmata, and a ringent monopetalous flower; the fruit is a bilocular capsule, with several seeds in each cell. There are three species.

MIMUSOPS, a genus of the octandria monogynia class of plants, the corolla of which consists of eight petals; and its fruit is a drupe. There are three species, trees of the East Indies.

MINA, in Grecian antiquity, a money of account, equal to a hundred drachms.

MINE, a deep pit under ground, whence various kinds of minerals are dug out; but the term is more particularly applied to those which yield metals. Where stones only are procured, the appellation of quarries is universally bestowed upon the places from which they are dug out, however deep they may be.

The internal parts of the earth, as far as they have been yet investigated, do not consist of one uniform substance, but of various strata or beds of substances, extremely different in their appearances, specific gravities, and chemical qualities, from one another. Neither are these strata similar to one another, either in their nature or appearance, in different countries; so that, even in the short extent of half a mile, the strata will be found quite different from what they are in another place. As little are they the same either in depth or solidity. Innumerable cracks and fissures, by the miners called lodes, are found in every one of them; but these are so entirely different in size and shape, it is impossible to form any inference from their size in one place to that in another. In these lodes or fissures the metallic ore is met with; and, considering the great uncertainty of the dimensions of the lodes, it is evident that the business of mining, which depends on that size, must in like manner be quite uncertain and precarious.

The insides of the fissures are commonly coated over with a hard, crystalline, earthy substance or rind, which very often, in the breaking of hard ore, comes off along with it; and is commonly called the capels or walls of the lode.

The breadth of a lode is easily known by the distance betwixt the two incrusted sides of the stones of ore; and if a lode yields any kind of ore, it is a better sign that the walls are regular and smooth, or at least that one of them is so, than otherwise; but there are not many of these fissures which have regular walls until they have been sunk down some fathoms.

Thus the inner part of the fissure in which the ore lies is all the way bounded by two walls of stone, which are generally parallel to one another, and include the breadth of the vein or lode. Whatever angle of inclination some fissures make in the solid strata at their beginning, they generally continue to do the same all along. Some are very uncertain in their breadth, as they may be small at their upper part and wider underneath; and vice versa. Their regular breadth, as well as their depth, is subject to great variation; for though a fissure may be many fathoms wide in one particular place, yet a little farther east or west it may not perhaps be one inch wide. This excessive variation happens generally in very compact strata, when the vein or fissure is squeezed, in a manner, through hard rocks which seem to compress and straiten it. A true vein or fissure, however, is never entirely obliterated, but always shows a string of metallic ore, or of a veiny substance; which often serves as a leader for the miners to follow, until it sometimes leads them to a large and richly impregnated part. Their length is, in a great measure, unlimited, though not the space best fitted for yielding metal. The richest state for copper is from 40 to 80 fathoms deep; for tin, from 20 to 60; and though a great quantity of either may be raised at 80 or 100 fathoms, yet "the quality is often too much decayed and dry for metal."

The fissures of veins of the Cornish mines extend from E. to W.; or, more properly, one end of the fissure points W. and by S., or W. and by N., while the other tends E. and by S. or E. and by N. Thus they frequently pass through a considerable tract of country with very few variations in their directions, unless they are interrupted by some intervening cause. But, besides this east and west direction, we are to consider what the miners call the underlying, or hade, of the vein or lode, viz. the deflection or deviation of the fissure from its perpendicular line, as it is followed in depth like the slope of the roof of a house, or the descent of the steep side of a hill. This slope is generally to the north or south; but varies much in different veins, or sometimes even in the same vein: for it will frequently slope or underlie a small space in different ways, as it may appear to be forced by hard strata on either side. Some of the fissures do not vary much from a perpendicular, while some deviate more than a fathom; that is, for every fathom they descend in perpendicular height, they deviate likewise as much to the south or north. Others differ so much from the perpendicular that they assume a position almost horizontal; whence they are also called horizontal or flat lodes, and sometimes lode-plots. Another kind of these has an irregular position with regard to the rest, widening horizontally for a little way, and then descending perpendicularly almost like stairs, with only a small string or leader to follow after; and thus they alternately vary, and yield ore in several flat or horizontal fissures. This, by the Cornish tinners, is called a floor or squat; which, properly speaking, is a hole or chasm impregnated with metal, making no continued line of direction or regular walls. Neither does a floor of ore descend to any considerable depth; for underneath it there appears no sign of a vein or fissure, either leading directly down, or any other way. This kind of vein is very rare in Britain. The fissures most common in Britain are the perpendicular and inclined, whether their direction is north or south, east or west.

The perpendicular and horizontal fissures probably remain little altered from their first position, when they were formed at the induration of the strata immediately after the waters left the land. The perpendicula fissures are found more commonly situated in level ground, at a distance from hills, and from the sea-shore; but with regard to the latter, we find that the upper and under masses of strata differ in their solidity and other properties. "Hence it is very plain that inclined fissures owe their deflection or underlie to some secondary cause, violence, or subsidence of the earth; for though perpendicular fissures are seldom to be seen, yet such as are inclined at very considerable depths become more and more perpendicular, as the more central strata, from the vast superincumbent weight, do not seem so likely to be driven out of their position as those which lie nearer the surface."

The fissures are often met with fractured as well as inclined; the reason of which has probably been a subsidence of the earth from some extraordinary cause. Though the metallic veins generally run from east to west, they are frequently intersected by veins or lodes of other matters, which run from north to south. Some of these cross veins contain lead or antimony, but never tin or copper. Sometimes one of these unmetallic veins intersects the true one at right angles; sometimes obliquely; and sometimes the mixture of both is so intimate, that the most expert miners are at a loss to discover the separated part of a true vein. When this last is intercepted at right angles, it is moved, either north or south, a very little way, perhaps not more than one fathom; in which case the miners having worked to a small distance in one of these directions, if they find themselves disappointed, turn to the other hand, and seldom fail of meeting with what they expected. Sometimes they are directed in their search by the pointing of a rib or string of the true vein; but when the interruption happens in an oblique direction, the difficulty of finding the vein again is much greater.

When two metallic veins in the neighbourhood of each other run in an oblique direction, and of consequence meet together, they commonly produce a body of ore at the place where they intersect; and if both are rich, the quantity will be considerable; but if one is poor and the other rich, then both are either enriched or impoverished by the meeting. After some time they separate again, and each will continue its former direction near to the other; but sometimes, though rarely, they continue united.

It is a sign of a poor vein when it separates or diverges into strings; but, on the contrary, when several of them are found running into one, it is accounted a promising sign. Sometimes there are branches without the walls of the vein in the adjacent strata, which often come either obliquely or transversely into it. If these branches are impregnated with ore, or if they underlie faster than the true vein (that is, if they dip deeper into the ground), then they are said to overtake or come into the lode, and to enrich it; or if they do not, then they are said to go off from it, and to impoverish it. But neither these, nor any other, marks, either of the richness or poverty of a mine, are entirely to be depended upon; for

They are the same as mentioned in the Philosophical Transactions, No. 222, page 298, by sir Hans Sloane, as being thrown ashore on the Hebrides and Orkneys.

This bean, after being long soaked in water, is boiled and eaten by some negroes; but, in general, there seems to be no other use made of it than as a sort of snuff-box.

15. The catechu, according to Mr. Ker (Med. Obs. and Inquir. vol. v. p. 151, &c.), grows only to 12 feet in height, and to one foot in diameter; it is covered with a thick, rough, brown bark, and towards the top divides into many close branches: the leaves are bipinnated, or doubly winged, and are placed alternately upon the younger branches: the partial pinnæ are nearly two inches long, and are commonly from 15 to 30 pair, having full glands inserted between the pinnæ: each wing is usually furnished with about 40 pair of pinnulæ, or linear lobes, beset with short hairs: the spines are short. From this tree, which grows plentifully on the mountainous parts of Indostan, where it flowers in June, is produced the officinal drug long known in Europe by the name of terra japonica.

16. The nilotica, or true Egyptian acacia, rises to a greater height than the preceding. The fruit is a long pod, resembling that of the lupin, and contains many flattish brown seeds. It is a native of Arabia and Egypt, and flowers in July. Although the mimosa nilotica grows in great abundance over the vast extent of Africa, yet gum arabic is produced chiefly by those trees which are situated near the equatorial regions; and we are told that in Lower Egypt the solar heat is never sufficiently intense for this purpose. The gum exudes in a liquid state from the bark of the trunk and branches of the tree, in a similar manner to the gum which is often produced upon the cherry-trees, &c. in this country; and by exposure to the air it soon acquires solidity and hardness. In Senegal the gum begins to flow when the tree first opens its flowers; and continues during the rainy season till the month of December, when it is collected for the first time. Another collection of the gum is made in the month of March, from incisions in the bark, which the extreme dryness of the air at that time is said to render necessary. Gum arabic is now usually imported into England from Barbary, in large casks or hogsheads. The common appearance of this gum is well known; and the various figures which it assumes seem to depend upon a variety of accidental circumstances attending its transudation and concretion. Gum arabic of a pale yellowish colour is most esteemed; on the contrary, those pieces which are large, rough, of a roundish figure, and of a brownish or reddish hue, are found to be less pure, and are said to be produced from a different species of mimosa; but the Arabian and Egyptian gum is commonly intermixed with pieces of this kind, similar to that which comes from the coast of Africa near the river Senegal.

Gum arabic does not admit of solution by spirit or oil; but in twice its quantity of water it dissolves into a mucilaginous fluid, of the consistence of a thick syrup; and in this state answers many useful pharmaceutical purposes, by rendering oily, resinous, and pinguious substances, miscible with water. The glutinous quality of gum arabic is preferred to most other gums and mucilaginous substances, as a demulcent in coughs, hoarsenesses, and other catarrhal affections, in order to obtund irritating acrimonious humours, and to supply the loss of abraded mucus. It has been very generally employed in cases of ardor urinæ and strangury; but it is the opinion of Dr. Cullen, "that even this mucilage, as an internal demulcent, can be of no service beyond the alimentary canal."

17. The senegal is a native of Guinea, and was some time ago introduced into Jamaica. The flowers are globular, yellow and fragrant. The pods are brown, and of the size of a goose-quill. The tree, on being wounded, exudes gum arabic, though in less quantity, and less transparent, than that of the shops, which is obtained from the nilotica above described.

There are above 40 other species characterised in the Systema Vegetabilium.

MIMULUS, *monkey flower*, a genus of the didynamia angiospermia class of plants, with double stigmata, and a ringent monopetalous flower; the fruit is a bilocular capsule, with several seeds in each cell. There are three species.

MIMUSOPS, a genus of the octandria monogynia class of plants, the corolla of which consists of eight petals; and its fruit is a drupe. There are three species, trees of the East Indies.

MINA, in Grecian antiquity, a money of account, equal to a hundred drachms.

MINE, a deep pit under ground, whence various kinds of minerals are dug out; but the term is more particularly applied to those which yield metals. Where stones only are procured, the appellation of quarries is universally bestowed upon the places from which they are dug out, however deep they may be.

The internal parts of the earth, as far as they have been yet investigated, do not consist of one uniform substance, but of various strata or beds of substances, extremely different in their appearances, specific gravities, and chemical qualities, from one another. Neither are these strata similar to one another, either in their nature or appearance, in different countries; so that, even in the short extent of half a mile, the strata will be found quite different from what they are in another place. As little are they the same either in depth or solidity. Innumerable cracks and fissures, by the miners called lodes, are found in every one of them; but these are so entirely different in size and shape, it is impossible to form any inference from their size in one place to that in another. In these lodes or fissures the metallic ore is met with; and, considering the great uncertainty of the dimensions of the lodes, it is evident that the business of mining, which depends on that size, must in like manner be quite uncertain and precarious.

The insides of the fissures are commonly coated over with a hard, crystalline, earthy substance or rind, which very often, in the breaking of hard ore, comes off along with it; and is commonly called the capels or walls of the lode.

The breadth of a lode is easily known by the distance betwixt the two incrusted sides of the stones of ore; and if a lode yields any kind of ore, it is a better sign that the walls are regular and smooth, or at least that one of them is so, than otherwise; but there are not many of these fissures which have regular walls until they have been sunk down some fathoms.

Thus the inner part of the fissure in which the ore lies is all the way bounded by two walls of stone, which are generally parallel to one another, and include the breadth of the vein or lode. Whatever angle of inclination some fissures make in the solid strata at their beginning, they generally continue to do the same all along. Some are very uncertain in their breadth, as they may be small at their upper part and wider underneath; and vice versa. Their regular breadth, as well as their depth, is subject to great variation; for though a fissure may be many fathoms wide in one particular place, yet a little farther east or west it may not perhaps be one inch wide. This excessive variation happens generally in very compact strata, when the vein or fissure is squeezed, in a manner, through hard rocks which seem to compress and straiten it. A true vein or fissure, however, is never entirely obliterated, but always shows a string of metallic ore, or of a veiny substance; which often serves as a leader for the miners to follow, until it sometimes leads them to a large and richly impregnated part. Their length is, in a great measure, unlimited, though not the space best fitted for yielding metal. The richest state for copper is from 40 to 80 fathoms deep; for tin, from 20 to 60; and though a great quantity of either may be raised at 80 or 100 fathoms, yet "the quality is often too much decayed and dry for metal."

The fissures of veins of the Cornish mines extend from E. to W.; or, more properly, one end of the fissure points W. and by S., or W. and by N., while the other tends E. and by S. or E. and by N. Thus they frequently pass through a considerable tract of country with very few variations in their directions, unless they are interrupted by some intervening cause. But, besides this east and west direction, we are to consider what the miners call the underlying, or hade, of the vein or lode, viz. the deflection or deviation of the fissure from its perpendicular line, as it is followed in depth like the slope of the roof of a house, or the descent of the steep side of a hill. This slope is generally to the north or south; but varies much in different veins, or sometimes even in the same vein: for it will frequently slope or underlie a small space in different ways, as it may appear to be forced by hard strata on either side. Some of the fissures do not vary much from a perpendicular, while some deviate more than a fathom; that is, for every fathom they descend in perpendicular height, they deviate likewise as much to the south or north. Others differ so much from the perpendicular that they assume a position almost horizontal; whence they are also called horizontal or flat lodes, and sometimes lode-plots. Another kind of these has an irregular position with regard to the rest, widening horizontally for a little way, and then descending perpendicularly almost like stairs, with only a small string or leader to follow after; and thus they alternately vary, and yield ore in several flat or horizontal fissures. This, by the Cornish tinners, is called a floor or squat; which, properly speaking, is a hole or chasm impregnated with metal, making no continued line of direction or regular walls. Neither does a floor of ore descend to any considerable depth; for underneath it there appears no sign of a vein or fissure, either leading directly down, or any other way. This kind of vein is very rare in Britain. The fissures most common in Britain are the perpendicular and inclined, whether their direction is north or south, east or west.

The perpendicular and horizontal fissures probably remain little altered from their first position, when they were formed at the induration of the strata immediately after the waters left the land. The perpendicula fissures are found more commonly situated in level ground, at a distance from hills, and from the sea-shore; but with regard to the latter, we find that the upper and under masses of strata differ in their solidity and other properties. "Hence it is very plain that inclined fissures owe their deflection or underlie to some secondary cause, violence, or subsidence of the earth; for though perpendicular fissures are seldom to be seen, yet such as are inclined at very considerable depths become more and more perpendicular, as the more central strata, from the vast superincumbent weight, do not seem so likely to be driven out of their position as those which lie nearer the surface."

The fissures are often met with fractured as well as inclined; the reason of which has probably been a subsidence of the earth from some extraordinary cause. Though the metallic veins generally run from east to west, they are frequently intersected by veins or lodes of other matters, which run from north to south. Some of these cross veins contain lead or antimony, but never tin or copper. Sometimes one of these unmetallic veins intersects the true one at right angles; sometimes obliquely; and sometimes the mixture of both is so intimate, that the most expert miners are at a loss to discover the separated part of a true vein. When this last is intercepted at right angles, it is moved, either north or south, a very little way, perhaps not more than one fathom; in which case the miners having worked to a small distance in one of these directions, if they find themselves disappointed, turn to the other hand, and seldom fail of meeting with what they expected. Sometimes they are directed in their search by the pointing of a rib or string of the true vein; but when the interruption happens in an oblique direction, the difficulty of finding the vein again is much greater.

When two metallic veins in the neighbourhood of each other run in an oblique direction, and of consequence meet together, they commonly produce a body of ore at the place where they intersect; and if both are rich, the quantity will be considerable; but if one is poor and the other rich, then both are either enriched or impoverished by the meeting. After some time they separate again, and each will continue its former direction near to the other; but sometimes, though rarely, they continue united.

It is a sign of a poor vein when it separates or diverges into strings; but, on the contrary, when several of them are found running into one, it is accounted a promising sign. Sometimes there are branches without the walls of the vein in the adjacent strata, which often come either obliquely or transversely into it. If these branches are impregnated with ore, or if they underlie faster than the true vein (that is, if they dip deeper into the ground), then they are said to overtake or come into the lode, and to enrich it; or if they do not, then they are said to go off from it, and to impoverish it. But neither these, nor any other, marks, either of the richness or poverty of a mine, are entirely to be depended upon: for

many mines, which have a very bad appearance at first, do nevertheless turn out extremely well afterwards; while others, which in the beginning seemed very rich, turn gradually worse and worse: but, in general, where a vein has had a bad appearance at first, it will be imprudent to be at much expense with it.

Veins of metal, as has been already observed, are frequently so compressed betwixt hard strata that they are not an inch wide; nevertheless, if they have a string of good ore, it will generally be worth while to pursue them; and they frequently turn out well at last, after they have come into softer ground. In like manner, it is an encouragement to go on if the branches or leaders of ore enlarge either in width or depth as they are worked; but it is a bad sign if they continue horizontal without inclining downwards; though it is not proper always to discontinue the working of a vein which has an unfavourable aspect at first. Veins of tin are worth working when only three inches wide, provided the ore is good; and copper ores when six inches wide will pay very well for the working. Some of the great mines, however, have very large veins, with a number of other small ones very near each other. There are also veins crossing one another sometimes met with: which are called contras, vulgarly caunters. Sometimes two veins run down into the ground in such a manner that they meet in the direction of their depth; in which case the same observations apply to them as are applicable to those that meet in an horizontal direction. Sometimes a vein will suddenly disappear without giving any warning, by becoming narrower, or of worse quality; which by the miners is called a start or leap, and is very common in the mines of Cornwall. In one day's time they may thus be disappointed in the working a rich vein of tin, and have no further sign of any thing to work upon: at the fractured extremity of their vein they perceive a body of clay or other matter; and the method of recovering their vein is to drive on their work in the direction of the former part, so that their new work shall make the same angle with the clay that the other part of the vein does. Sometimes they sink a shaft down from the surface; but it is generally a matter of difficulty to recover a vein when thus lost.

The method of discovering mines is a matter of so much difficulty, that it seems surprising how those who were totally unacquainted with the nature of metals first came to think of digging them out of the earth. In modern times we know that mines have been frequently discovered by accident; as in sea-cliffs, among broken craggy rocks, by the washing of the tides or floods; also by irruptions and torrents of water issuing out of hills and mountains, and sometimes by the wearing of high roads.

Mines, however, are now most commonly discovered by investigating the nature of such veins, ores, and stones, as may seem most likely to turn to account: but there is a particular sagacity, or habit of judging from particular signs, which can be acquired only by long practice. Mines, especially those of copper, may be also discovered by the harsh and disagreeable taste of the waters which issue from them; though it is probable that this only happens when the ore lies above the level of the water which breaks out; for it does not seem likely that the taste of the ore could ascend, unless we were to suppose a pond or lake of water standing above it. The presence of copper in any water is easily discovered by immerging in it a bit of polished iron, which will thus instantly be turned of a copper colour, from the precipitation of the metal upon it. A candle, or a piece of tallow, put into water of this kind, will in a short time be tinged of a green colour.

After the mine is found, the next thing to be considered is, whether it may be dug to advantage. In order to determine this, we are duly to weigh the nature of the place, and its situation, as to wood, water, carriage, healthiness, and the like; and compare the result with the richness of the ore, the charge of digging, stamping, washing, and smelting.

The form and situation of the spot should be particularly well considered. A mine must either happen, 1. in a mountain; 2. in a hill; 3. in a valley; or, 4. in a flat. But mountains and hills are dug with much greater ease and convenience, chiefly because the drains and burrows, that is, the adits or avenues, may be here readily cut, both to drain the water, and to form gangways for bringing out the lead, &c. In all the four cases, we are to look out for the veins which the rains or other accidental circumstances may have laid bare; and if such a vein is found, it may often be proper to open the mine at that place, especially if the vein proves tolerably large and rich: otherwise the most commodious place for situation is to be chosen for the purpose, viz. neither on a flat, nor on the top of mountains, but on the sides. The best situation for a mine is a mountainous, woody, wholesome spot; of a safe easy ascent, and bordering on a navigable river. The places abounding with mines are generally healthy, as standing high, and every where exposed to the air; yet some places where mines are found prove poisonous, and can upon no account be dug.

Devonshire and Cornwall, where there are a great many mines of copper and tin, are a very mountainous country, which gives an opportunity in many places to make adits or subterraneous drains to some valley at a distance, by which to carry off the water from the mine, which otherwise would drown them out from getting the ore. These adits are sometimes carried a mile or two, and dug at a vast expense, as from 2000*l.* to 4000*l.* especially where the ground is rocky; and yet they find this cheaper than to draw up the water out of the mine quite to the top, when the water runs in plenty, and the mine is deep. Sometimes, indeed, they cannot find a level near enough to which an adit may be carried from the very bottom of the mine; yet they find it worth while to make an adit at half the height to which the water is to be raised, thereby saving half the expense.

The late Mr. Costar, considering that sometimes from small streams, and sometimes from little springs or collections of rain-water, one might have a good deal of water above ground, though not a sufficient quantity to turn an overshot-wheel, thought, that if a sufficient fall might be had, this collection of water might be made useful in raising the water in a mine to the adit, where it might be carried off. But now the most general method of draining mines is by the steam-engine.

A Mine (in military affairs) is also a subterraneous cavity made according to the rules of art, in which a cer-

tain quantity of powder is lodged, which by its explosion blows up the earth above it.

It has been found by experiment that the figure produced by the explosion is a paraboloid; and that the centre of the powder, or charge, occupies the focus.

The place where the powder is lodged is called the chamber of the mine, or forneau.

The passage leading to the powder is called the gallery.

The line drawn from the centre of the chamber; perpendicular to the nearest surface of the ground, is called the line of least resistance.

The pit or hole, made by springing the mine, is called the excavation.

The fire is communicated to the mine by a pipe or hose, made of coarse cloth, whose diameter is about one inch and a half, called a saucission (for the filling of which near half a pound of powder is allowed to every foot), extending from the chamber to the entrance of the gallery; to the end of which is fixed a match, that the miner who sets fire to it may have time to retire before it reaches the chamber.

To prevent the powder from contracting any dampness, the saucission is laid in a small trough, called an auget, made of boards, three inches and a half broad, joined together lengthwise, with straw in it, and round the saucission, with a wooden cover nailed upon it.

Galleries and chambers of mines.—Galleries made within the fortification, before the place is attacked, and from which several branches are carried to different places, are generally four feet or four and a half wide, and five or five and a half high. The earth is supported from failing in by arches and walls, if they are to remain for a considerable time; but when mines are made to be used in a short time, then the galleries are but three feet or three and a half wide, and five feet high, and the earth is supported by wooden frames or props.

The gallery being carried on to the place where the powder is to be lodged, the miners make the chamber. This is generally of a cubical form, large enough to hold the wooden box, which contains the powder necessary for the charge: the box is lined with straw and sand-bags, to prevent the powder from contracting dampness.

The chamber is sunk sometimes lower than the gallery, if the soil permits; but where water is to be apprehended, it must be made higher than the gallery; otherwise the besieged will let in the water, and spoil the mine.

Quantities of powder to charge mines.—Before any calculation can be made of the proper charge for a mine, the density and tenacity of the soil in which it is to be made must be ascertained, either by experiment, or otherwise; for in soils of the same density, that which has the greatest tenacity will require the greatest force to separate its parts. The density is determined by weighing a cubic foot (or any certain quantity) of the soil; but the tenacity can only be determined by making a mine. The following table contains experiments in six different soils, which may be of some assistance to form a judgment of the nature of the soil, when an actual experiment cannot be had:

Nature of the Soil.	Density.	Tenacity.
	Weight of one cubic foot.	Quantity of powder to raise one cub. fath.
1. Loose earth or sand	95 pds.	8 pds.
2. Common light soil	124	10
3. Loam, or strong soil	127	$12\frac{1}{4}$
4. Potter's clay, or stiff soil	135	$13\frac{1}{2}$
5. Clay, mixed with stones	160	16
6. Masonry	205	$21\frac{1}{2}$

Loading and stopping of mines.—The gallery and chamber being ready to be loaded, a strong box of wood is made of the size and figure of the chamber, being about one-third or one-fourth bigger than is required for containing the necessary quantity of powder: against the sides and bottom of the box is put some straw: and this straw is covered over with empty sand-bags, to prevent the powder from contracting any dampness: a hole is made in the side next the gallery, near the bottom, for the saucisson to pass through; which is fixed to the middle of the bottom, by means of a wooden peg, to prevent its loosening from the powder: or that, if the enemy should get to the entrance, he may not be able to tear it out. This done, the powder is brought in sand bags, and thrown loose in the box, and covered also with straw and sand-bags; upon this is put the cover of the box, pressed down very tight with strong props; and, to render them more secure, planks are also put above them, against the earth, and wedged in as fast as possible.

This done, the vacant spaces between the props are filled up with stones and dung, and rammed in the strongest manner: the least neglect in this work will considerably alter the effect of the mine.

The auget is then laid from the chamber to the entrance of the gallery, with some straw at the bottom; and the saucission laid in it, with straw over it: lastly, it must be shut with a wooden cover nailed upon it. Great care must be taken, in stopping up the gallery, not to press too hard upon the auget, for fear of spoiling the saucisson; which may hinder the powder from taking fire, and so prevent the mine from springing. The gallery is stopped up with stones, earth, and dung, well rammed, six or seven feet further from the chamber than the length of the line of least resistance.

MINERAL WATERS. See Waters.

MINERALOGY, is that science which treats of the solid and inanimate materials of which our globe consists; and these are usually arranged under four classes: the earthy, the saline, the inflammable, and the metallic, which are thus distinguished:

1. The earthy minerals compose the greater part of the crust of the earth, and generally form a covering to the rest. They are not remarkable for being heavy, brittle, or light-coloured. They are little disposed to chrys-

tallize, are uninflammable in a low temperature, insipid, and without much smell.

2. The saline minerals are commonly moderately heavy, soft, sapid, and possess some degree of transparency.

3. The inflammable class of minerals is light, brittle, mostly opaque, of a yellow, brown, or black colour, seldom chrystallize, and never feel cold.

4. Metallic minerals are characterized by being heavy, generally opaque, tough, malleable, cold, not easily inflamed, and by exhibiting a great variety of colours, of a peculiar lustre.

Under each of these classes are various genera, species, sub-species and kinds, which will be noticed in order. Sometimes, as in the vegetable kingdom, we find a strict affinity between different species of minerals, and in that case they are said to belong to the same family; but in mineralogy, one class does not always blend with another in a chemical point of view, or furnish that beautiful gradation and almost imperceptible union which is to be traced in the other kingdoms of nature.

As the external characters are of the first importance in facilitating our acquaintance with minerals, we shall briefly explain this subject, before we proceed to the classification of the different substances.

Of the external characters of Minerals.

The external characters of minerals are either generic or specific. The generic characters are certain properties of minerals, without any reference to their differences, as colour, lustre, weight, &c.; and the differences between these properties form the specific characters.

Generic characters may be general or particular. In the first division are comprehended those that occur in all minerals, in the last those that are found only in particular classes of minerals.

The particular generic external characters are thus advantageously arranged:

1. Colour.

2. Cohesion of particles; distinguished into solid, friable, and fluid.

In solid minerals are to be regarded the external shape, the external surface, and the external lustre. When broken, the lustre of the fracture, the fracture itself, and the shape of the fragments, are to be noticed. In distinct concretions, regard must be paid to the shape of the concretions, their surface, their lustre, transparency, streak, and soiling. All these may be ascertained by the eye. By the touch, we may discover the hardness of minerals, their tenacity, frangibility, flexibility, their unctuosity, coldness, weight, and their adhesion to the tongue. By the ear we distinguish their sound, and by the smell and taste the qualities which these two senses indicate.

In friable minerals, external shape, lustre, aspect of particles, soiling, and degree of friability, are to be attended to.

In fluid minerals the lustre, transparency, and fluidity, are principal objects to be regarded.

The specific external characters of minerals are founded on the distinctions and varieties of the two great generic divisions. And first, of colours, the names of which are derived from certain bodies in which they most generally occur, either in a natural or artificial state, or from different mixtures and compositions of both.

I. Colour.

1. White. This may be snow-white, reddish-white, yellowish-white, silver-white, greyish-white, greenish-white, milk-white, or tin-white.

2. Grey. Lead-grey, bluish-grey, pearl-grey, reddish-grey, smoke-grey, greenish-grey, yellowish-grey, steel-grey, and ash-grey.

3. Black. Greyish-black, brownish-black, dark-black, iron-black, greenish-black, and blueish-black.

4. Blue. Indigo-blue, Prussian-blue, lavender-blue, smalt-blue, sky-blue.

5. Green. Verdigris-green, celaden-green, mountain-green, emerald-green, leek-green, apple-green, grass-green, pistachio-green, asparagus-green, olive-green, blackish-green, canary-green.

6. Yellow. Sulphur-yellow, lemon-yellow, gold-yellow, bell-metal-yellow, straw-yellow, wine-yellow, Isabella-yellow, ochre-yellow, orange-yellow, honey-yellow, wax-yellow, brass-yellow.

7. Red. Morning-red, hyacinth-red, brick-red, scarlet-red, copper-red, blood-red, carmine-red, cochineal-red, crimson-red, columbine-red, flesh-red, rose-red, peach-blossom-red, cherry-red, brownish-red.

8. Brown. Reddish-brown, clove-brown, hair-brown, yellowish-brown, tombac-brown, wood-brown, liver-brown, blackish-brown.

Besides these distinctions, colour may be clear, dark, light, or pale; they may have a tarnished appearance, a play, a changeability, an iridescence, an opalescence, a permanent alteration, and delineation of figure or pattern, such as dotted, spotted, clouded, flamed, striped, veined, dendritic, or ruiniform.

II. Cohesion of Particles.

Minerals are divided into, 1. Solid, or such as have their parts coherent, and not easily moveable; 2. Friable, or that state of aggregation in which the particles may be overcome by simple pressure of the finger; and, 3. Fluid, or such as consist of particles which alter their place in regard to each other by their own weight.

1. *Solid minerals.*

External aspect has three things to be regarded, 1. The shape; 2. The surface; and 3. The lustre. The external shape again may be common, particular, regular, or extraneous; and hence arise the specific differences.

1. The common external shape may be massive; disseminated coarsely, minutely, or finely; in angular pieces, sharp-cornered or blunt-cornered; in grains, large, coarse, small, fine, angular, flat, round; in plates, thick or thin; in membranes or flakes, thick, thin, or very thin.

The particular external shape may be longish, as dentiform, filiform, capillary, reticulated, dendritic, coralliform, stalactitic, cylindrical, tubiform, claviform, or fruticose; roundish, as globular, spherical, ovoidal, spheroidal, amygdaloidal, botryoidal, reniform, tuberose, or fused-like; flat, as specular, or in leaves; cavernous, as cellular in various forms, with impressions, perforated, corroded, amorphous, or vesicular; entangled, as ramose, &c.

In the regular external shape or crystallization are to be regarded its genuineness, according to which it may be either true or suppositious; its shape, made up of planes, edges, angles, in which are to be observed the

fundamental figure and its parts, the kind of fundamental figure, the varieties of each kind of fundamental figure, with their accidents and distinctions, and the alterations which the fundamental figure undergoes by truncation, by bevelment, by acumination, or by a division of the planes. There are a variety of figures under each of these subdivisions.

It must be remarked also that the external shape may be extraneous, or derived from the animal and vegetable kingdoms, as in fossils and petrifications.

2. The external surface contains several varieties of distinctions. It may be uneven, granulated, rough, smooth, or streaked in various ways and directions.

3. The external lustre is the third generic external character, and is of much importance to be attended to. In this we have to consider the intensity of the lustre, whether it is splendent, shining, glistening, glimmering, or dull; next the sort of lustre, whether metallic or common. The latter is distinguished into semimetallic, adamantine, pearly, resinous, and vitreous.

Aspect of the Fracture of solid Minerals.

After the external aspect, the fracture forms no inconsiderable character in minerals. Its lustre may be determined as in the external lustre: but the fracture itself admits of great varieties. It may be compact, splintery, coarsely splintery, finely splintery, even, conchoidal, uneven, earthy, hackly. If the fracture is fibrous, we are to consider the thickness of the fibres, if coarse or delicate; the direction of the fibres, if straight or curved; and the position of the fibres, if parallel or diverging.

In the radiated fracture we are to regard the breadth of the rays, their direction, their position, their passage or cleavage. In the foliated fracture, the size of the folia, their degree of perfection, their direction, position, aspect of their surface, passage or cleavage, and the number of cleavages, are to be noted.

The shape of the fragments may also be very various-regular, as cubic, rhomboidal, trapezoidal, &c. or irregular, as cuneiform, splintery, tabular, indeterminately angular.

Aspect of the distinct Concretions.

The shape of the distinct concretions forms very prominent external characters. They may be granular, different in shape, or in magnitude; they may be lamellar, distinct, concretious, differing in the direction of the lamellæ, in the thickness, with regard to shape, and in the position.

The surface of the distinct concretions may be smooth, rough, streaked, or uneven; as for their lustre, it may be determined in the same manner as the external lustre.

General Aspect as to Transparency.

Minerals, as is well known, have different degrees of transparency, which may be considered among their external characters. They may be transparent, semitransparent, translucent, translucent at the edges, or opaque.

The Streak.

The colour of this external character may be either similar or different. It is presented to us when a mineral is scraped with the point of a knife: and is similar, when the powder that is formed is of the same colour with the mineral, as in chalk; or dissimilar or different, as in cinnabar, orpiment, &c.

The Soiling or Colouring

Is ascertained by taking any mineral substance between the fingers, or drawing it across some other body. It may soil strongly, as in chalk, slightly, as in molybdena, or not all, which is a quality belonging to most of the solid minerals. All the preceding external characters are recognized by the eye.

External Characters from the Touch.

These are eight in number, and are not destitute of utility to the mineralogical student. 1. Hardness; 2. Tenacity; 3. Frangibility; 4. Flexibility; 5. Adhesion to the tongue; 6. Unctuosity; 7. Coldness; 8. Weight.

Hardness may be tried by a capacity to resist the file, yielding a little to it, by being semi-hard, soft, or very soft. Tenacity has different degrees, in substances being brittle, sectile or mild, or ductile. The frangibility consists in minerals being very difficultly frangible, difficultly frangible, easily frangible, or very easily frangible. The flexibility is proved by being simply flexible, elasticly flexible, commonly flexible, or inflexible. The adhesion to the tongue may be strongly adhesive, pretty strongly, weakly, very weakly, or not at all. Unctuosity may be meagre, rather greasy, or very greasy. Coldness is subdivided into cold, pretty cold, rather cold. Weight may be distinguished into swimming or supernatant, light, rather light, heavy, very heavy. The three last divisions from the touch, are in the Wernerian system regarded as anomalous; but they seem properly to be classed under this head.

External Characters from the Sound or Hearing.

The different kinds of sound which occur in the mineral kingdom are, 1. A ringing sound, as in native arsenic and thin splinters of horn-stone; 2. A grating sound, as in fresh-burnt clay; 3. A creaking sound, as that of natural amalgam.

2. *Friable Minerals.*

The external characters drawn from minerals of this class are derived, first, from the external shape, which may be massive, disseminated, thinly coating, spumous, or dendritic: secondly, from the lustre, regarded under its intensity, whether glimmering or dull, and its sort, whether common glimmering or metallic glimmering: thirdly, from the aspect of the particles, as being dusty or scaly: fourthly, from soiling or colouring, as strongly or lightly: and lastly, from the friability, which may be loose or cohering.

3. *Fluid Minerals.*

Of external characters drawn from fluid minerals, there are only two kinds, which include three varieties: 1. The lustre, which is either metallic, as in mercury, or resinous, as in rock oil. 2. The transparency, which is transparent, as in naphtha; turbid, as in mineral oil; or opaque, as in mercury. 3. The fluidity, which may be fluid, as in mercury, or viscid, as in mountain tar.

External Characters from the Smell.

These may be spontaneously emitted and described, as bituminous, faintly sulphureous, or faintly bitter; or they may be produced by breathing on, and yield a clay-like smell; or they may be excited by friction, and smell urinous, sulphureous, garlick-like, or empyreumatic.

External Character from the Taste.

This character prevails chiefly in the saline class, and it contains the following varieties: a sweetish taste,

sweetish astringent, styptic, saltly bitter, saltly cooling, alkaline, or urinous.

Having now given a synoptical view of the external characters of minerals, we shall proceed to their classification, and in this we shall chiefly follow the names and arrangement of professor Jameson.

CLASS I.

EARTHY FOSSILS.

First Genus. DIAMOND.

Diamond.

This precions stone has great variety of shades, exhibiting a beautiful play of colours. It occurs in indeterminately angular and completely spherical grains, which present planes of chrystallization, or are actually chrystallized. Its fundamental chrystal is the octahedron, which passes into various forms. It is hard in the highest degree, brittle, not very difficulty frangible, and has a specific gravity of 3.600.

The diamond has, by modern experiments, been proved to be nearly pure carbon, and begins to burn at 14° or 15° of Wedgewood. See Plate LXXXIX. Mineralogy, figs. 1. and 2.

Second Genus. ZIRCON.

First Species. *Zircon.*

The prevailing colour is grey, but it occurs likewise green, blue, red, yellow, and brown, with various intermediate tints.

It is found most commonly in roundish angular pieces, with rounded angles and edges. When crystallized, the figure is generally a rectangular four-sided prism, somewhat flatly acuminated by four planes, set on lateral planes; but of this figure there are several varieties. The chrystals are almost always very small, have a smooth surface, bordering on strongly splendent. Internally, the lustre is strongly splendent, passing into adamantine. Fig. 3.

Zircon is hard in a very high degree, brittle, frangible without great difficulty. Specific gravity 4.700. It forms a colourless transparent mass with borax, but is infusible by the blowpipe without addition.

Found in the island of Ceylon, where it was first discovered, and lately in Norway, imbedded in a rock composed of hornblende and felspar. [It occurs also in primitive rocks near Trenton in New-Jersey. See Bruce's Journal, page 127.]

Frequently cut as a precious stone, and used as an inferior kind of diamond, of which it was once considered as a variety. Its play of colours very considerable.

Second Species. *Hyacinth.*

The chief colour is red, passing to reddish-brown, and to orange-yellow. The figure a rectangular four-sided prism, flatly acnminated by four planes, which are set in the lateral edges. Of this figure, however, several varieties occur.

The chrystals are generally small, and always imbedded. The lateral planes smooth, and externally shining. Internally it is splendent and glassy, inclining somewhat to resinous. Fig. 4.

The hyacinth is transparent, very hard, frangible without particular difficulty, feels a little greasy when cut, and has a specific gravity of about 4.000.

Is fusible with borax. Exposed to the blowpipe it loses its colour, but not its transparency.

Occurs in rocks of the newest floetz trap formation, and sometimes in sand. Is a native of Ceylon, the country of gems; of Spain, of Portugal, France, Italy, Saxony, and probably Scotland.

It takes a fine polish, and when the colours are good, it is highly valued. A third species, called cinnamon stone, has lately been discovered at Columbo, in Ceylon.

Third Genus. FLINT.

First Species. *Chrysoberyl.*

The prevailing or general colour is asparagus-green, passing into a variety of allied shades. It exhibits a milk-white light; occurs in roundish and angular grains, which sometimes approach in shape to the cube. It is seldom chrystallized; but when in this state, it commonly presents a longish six-sided table, having truncated lateral edges, and longitudinally streaked lateral planes. The chrystals are small, externally shining, and internally splendent. Fig. 5.

It is hard, brittle, not very easily frangible, with a specific gravity of 3.600. Without addition, it is infusible.

The chrysoberyl is found in Brazil, and in the sand of Ceylon. It is sometimes set in rings with a yellow foil, but is rarely in the possession of our jewellers.

Second Species. *Chrysolite.*

The chief colour is pistachio-green, of all degrees of intensity. It occurs in original angular sharp-edged pieces, with a rough, scaly, splintery surface, and when chrystallized, exhibits a broad rectangular four-sided prism, with its lateral edges sometimes truncated, sometimes bevilled, and acuminated by six planes. Fig. 6.

The external surface of the chrystals is splendent, internally splendent, and vitreous.

Third Species. *Olivine.*

The colour is generally asparagus-green, of varions degrees of intensity. It is found imbedded also in roundish pieces and grains; and when chrystallized, which is rare, in rectangular four-sided prisms.

Internally, it is shining, varying between glistening and splendent. It is semitransparent, very easy frangible; in a low degree hard, and not particularly heavy. It is nearly infusible without addition. Occurs imbedded in basalt; is frequently found in Bohemia, and also in Hungary, Austria, France, England, Ireland, Scotland, Sweden, Iceland, and Norway. Pieces as large as a man's head have been found in some parts of Germany.

Fourth Species. *Augite.*

The general colour is blackish-green. It occurs chiefly in indeterminate angular pieces and roundish grains. Occasionally it is chrystallized, and presents broad rectangular six-sided prisms. The chrystals are mostly small. Internally the lustre is shining, approaching sometimes to splendent.

The augite is only translucent, and but faintly transparent. It is hard, not very easily frangible, and not particularly heavy.

It is found in basalt, either singly or accompanied with olivine, in Bohemia, Hungary; at Arthur's-seat, near Edinburgh; in some of the Hebrides, and in Norway. From olivine it is distinguished by its darker colours, the form of its chrystallization, and its greater hardness,

Fifth Species. Vesuviane.

Its principal colour is dark olive-green, passing into other allied shades. It occurs massive, and often chrystallized in rectangular four-sided prisms. The chrystals are mostly short, and placed on one another. Externally their surface alternates between glistening and splendent. Internally they are glistening, with a lustre between vitreous and resinous.

The vesuviane is translucent, hard in a moderate degree, and approaching to heavy. Before the blowpipe it melts without addition.

It is found among the exuviæ of Vesuvius, from whence it derives its name, in Siberia and Kamtschatka. At Naples, it is cut into ring-stones, and sold under various names.

Sixth Species. Leuzite.

The colours are yellowish and greyish-white. It occurs mostly in original round and angular grains. When chrystallized, it exhibits acute double eight-sided pyramids. Internally it is shining, and approaching to glistening, with a vitreous lustre, inclining somewhat to resinous.

The leuzite is translucent and semitransparent. It is hard in a low degree, brittle, easily frangible, and not very heavy. It is infusible without addition. With borax, it forms a brownish transparent glass.

It is found in rocks of the newest floetz trap formation, particularly in basalt, near Naples, and in the vicinity of Rome. Bergman gave it the name of white garnet; but Werner has ascertained it to be a distinct species of itself.

Seventh Species. Melanite.

The general colour is velvet-black. It occurs crystallized in a six-sided prism. The chrystals are middle-sized or small. Externally they are smooth and shining, approaching to splendent; internally shining, inclining to glistening.

The melanite is opaque, hard, pretty easily frangible, and not very heavy. It occurs imbedded in rocks of the newest floetz trap formation, and hitherto has been found only at Frescati and St. Albano, near Rome.

Eighth Species. Garnet.

This is divided into two sub-species, the precious garnet and the common garnet. See GARNET, and fig. 7.

Ninth Species. Pyrope.

The colour is dark blood-red. It occurs in small and middle-sized roundish and angular grains; but never crystallized. Its lustre is splendent and vitreous. It is completely transparent, hard so as to scratch quartz, and not particularly heavy.

The pyrope is found imbedded in serpentine in Saxony and Bohemia. In Fifeshire, Scotland, it is found in the sand on the sea shore. It is employed in various kinds of jewellery, and is generally set in a good foil.

Tenth Species. Grenatite.

The colour is a dark reddish-brown. It is always crystallized in broad six-sided prisms. The crystals are small and middle-sized, internally glistening, with a lustre between vitreous and resinous.

The grenatite varies from opaque to translucent, is hard, brittle, easily frangible, and not particularly heavy.

It is found imbedded in mica slate, in St. Gothard, Switzerland; and is also met with in Britanny and in Spain.

Eleventh Species. Spinelle.

The predominant colour is red, which passes on into blue, green, yellow, and brown. It occurs in grains, and likewise chrystallized in octahedrons with several variations. The crystals are very rarely middle-sized. Externally and internally the lustre is splendent and vitreous.

The spinelle alternates from transparent to vitreous: it is hard in a pretty high degree, and approaches to heavy. It is fusible with borax: occurs in rocks belonging to the newest floetz trap formation; and is found in Pegu and Ceylon. It is used as a precious stone, and considerably valued, though possessing neither the hardness nor the fire of the oriental ruby.

Twelfth Species. Sapphire.

The principal colour Berlin blue: but it is found also red, with all the intermediate shades between these two colours. It occurs in small rolled pieces, and crystallized in double three-sided pyramids, of which there are several varieties in figure.

The chrystals are small and middle-sized. Internally the lustre is splendent and vitreous. It is more or less transparent in different specimens. Some varieties, when cut, exhibit a star of six rays. Fig. 8.

The sapphire is hard in the highest degree, but yields to the diamond; it is easily frangible, and rather heavy, having a specific gravity of about 4.000.

It is infusible without addition: occurs in rocks of the newest floetz trap formation, and is supposed to be an inmate of granite, syenite, and other primitive rocks.

This precious stone is found in the utmost beauty in Pegu and Ceylon. It is also a native of Portugal, of France, and of Bohemia. Next to the diamond, it is the most valuable of gems, and is used in the finest kind of jewellery.

It should be observed, that the violet-coloured sapphire is the oriental amethyst; that the yellow is the oriental chrysolite and topaz; and that the green is the oriental emerald.

Thirteenth Species. Corundum.

The principal colour is a greenish-white, of various degrees of intensity. It occurs massive, disseminated, in rolled pieces, and chrystallized. The chrystallizations resemble those of the sapphire, and the chrystals are middle-sized and imbedded.

The corundum is duplicating translucent, hard in a high degree, pretty easily frangible, and approaches to heavy. It is supposed to occur imbedded in granite, syenite, or green-stone, and is found in the Carnatic and on the coast of Malabar. See CORUNDUM.

Fourteenth Species. Diamond Spar.

The colour is a dark hair-brown. It occurs massive, disseminated, in rolled pieces, and chrystallized in six-sided prisms, or very acute six-sided pyramids. Internally, its lustre is splendent, approaching in a slight degree to adamantine. It may be cut so as to present an opalescent star of six rays, of a peculiar pearly light.

It is translucent on the edges, hard in a high degree, easily frangible, and not particularly heavy.

The diamond spar probably occurs in granite. It has hitherto been found only in China. Both this stone and

corundum are employed in cutting and polishing hard minerals, and they seem to be nearly allied to each other.

Fifteenth Species. Emery.

Emery is hard in the highest degree, not very easily frangible, and is heavy. It occurs in beds of talc and steatite, and is frequently accompanied with calcspar and blende. It is found in Saxony, in the islands of the Archipelago, in Spain, Normandy, and is said also to be a native of the isles of Guernsey and Jersey.

It is of great use in cutting and polishing hard bodies.

Sixteenth Species. Topaz.

The chief colour is a wine-yellow, of all degrees of intensity. It is found massive, disseminated, and sometimes rolled, but most commonly chrystallized in oblique eight-sided or four-sided prisms, which exhibit several varieties. The chrystals are small and middle-sized, externally splendent; internally splendent, and shining; lustre vitreous.

The topaz alternates from translucent to transparent, and is duplicating transparent. It is hard in a high degree, easily frangible, and is not particularly heavy. It is fusible with borax; and some kinds in a gentle heat turn white, and are sometimes sold for diamonds.

It is commonly found in veins that traverse primitive rocks in Brazil, Siberia, in Pegu, and Ceylon; in Bohemia, Saxony, and in Cornwall. Exhibiting various forms and tints, it has often been confounded with other precious stones. It is much used in seals and rings.

Seventeenth Species. Emerald.

The green called emerald is the characteristic colour of this species, but it has all degrees of intensity from deep to pale. It is said to occur massive and in rolled pieces, but most commonly chrystallized in low equiangular six-sided prisms. The chrystals are middle sized and small. Internally the lustre is intermediate between shining and splendent, and is vitreous. It alternates from transparent to translucent, and is duplicating transparent.

The emerald is hard, not particularly heavy, melts easily with borax, but is scarcely fusible before the blow-pipe. It occurs in veins that traverse clay-slate, and at present is only found in South America, particularly in Peru, though the Romans are said to have procured it from Egypt and Ethiopia.

From the beauty and vivacity of its colour, the charming emblem of the vegetable kingdom, this precious stone is much admired, and employed in the most expensive kinds of jewellery. See Emerald.

Eighteenth Species. Beryl.

This is divided into two sub-species, the precious and the schorlous beryl. See Beryl, and fig. 9.

Ninteenth Species. Schorl.

This is divided into two sub-species, common schorl and tourmaline. Fig. 10.

Twentieth Species. Thumerstone.

The colour is commonly clove-brown, of various degrees of intensity. It is occasionally found massive, more frequently disseminated; but generally chrystallized in very flat and oblique rhombs. Externally, its lustre is generally splendent; internally, it alternates from glistening to shining, and is vitreous.

This species alternates from perfectly transparent to weakly translucent. It is pretty hard, very easily frangible, and not particularly heavy. It appears to be peculiar to the primitive mountains, and is found imbedded in limestone in Saxony, Dauphiny, Norway, Siberia, and Cornwall. Fig. 11.

Twenty-first Species. Iron-Flint.

The colour a yellowish-brown, bordering on liver-brown. It occurs commonly massive, but also chrystallized in small equiangular six-sided prisms. Externally, its lustre is splendent; internally, shining, and is intermediate between vitreous and resinous.

Iron-flint is opaque, and slightly translucent on the edges. It is pretty hard, somewhat difficultly frangible, and approaching to heavy. It occurs in iron-stone veins, and is found in Saxony, and, according to Karsten, at Bristol. It renders the iron ore, along with which it is dug, very difficult of fusion.

Twenty-second Species. Quartz.

Werner divides this into five sub-species, amethyst, rock chrystal (fig. 12), milk-quartz, common quartz, and prase. The first sub-species is again subdivided into common amethyst and thick fibrous amethyst. See Quartz, Amethyst, &c.

Twenty-third Species. Horn-Stone.

Horn-stone is divided into three sub-species, splintery horn-stone, conchoidal horn-stone, and wood-stone.

First Sub-species. Splintery Horn-Stone.

The common colour grey, but often red, with various shades of each. It is usually found massive, or in large balls. Internally its lustre is dull; but glimmering, when it approaches to the nature of quartz. It is more or less translucent on the edges, hard, brittle, very difficultly frangible, and not particularly heavy.

The substance is infusible without addition; and is found in the shape of balls in limestone, and sometimes forming the basis of porphyry. It is a native of Bavaria, Sweden, and the Shetland islands; and appears to differ from quartz in containing a larger proportion of alumina.

Second Sub-species. Conchoidal Horn-Stone.

The colour runs from greyish white to yellowish and greenish-white. It occurs massive. Internally, it is a little glistening, strongly translucent on the edges, hard, easily frangible, and not particularly heavy.

Conchoidal horn-stone is found in beds or in veins, accompanied with agate, at Goldberg, in Saxony.

Third Sub-species, Wood-Stone.

The prevailing colour is ash-grey, but with many different shades. Its shape is exactly conformable to its former woody form, whether trunk, branches, or roots. Internally, it is sometimes dull, and sometimes glimmering and glistening; slightly translucent on the edges, pretty hard, easily frangible, and not particularly heavy.

It is found insulated in sandy loam in Saxony, Bohemia, Russia, Hungary, and at Loch Neagh in Ireland. It receives a good polish, and is applied to the same purposes as agate.

Twenty-fourth Species. Flint.

The general colour is grey, but with many varieties. It occurs massive, in regular plates, in angular grains and species, in globular and elliptical rolled pieces, in the form of sand, and tuberose and perforated. Some-

times it is chrystallized, when it exhibits double six-sided prisms, or flat double three-sided pyramids. Internally, the lustre is glimmering; translucent on the edges, hard, easily frangible, and not particularly heavy.

Twenty-fifth Species. Chalcedony.

This is divided into two sub-species, chalcedony and carnelian.

First Sub-species. Common Chalcedony.

The most common colour is grey. The external shape is various, being massive, in blunt-edged grains and rolled pieces, in original round balls, &c. &c. Internally, the chalcedony is almost always dull, commonly semitransparent, hard, brittle, rather difficultly frangible, and not particularly heavy. It occurs in amygdaloid, and in porphyry; and is found in Transylvania, in Iceland, Siberia, Cornwall, Scotland, and the Hebrides. Being susceptible of a fine polish, it is employed as an article of jewellery.

Second Sub-species. Carnelian.

The principal colour is a blood-red, of all degrees of intensity. It commonly occurs in roundish pieces, and also in layers: the lustre is glistening, bordering on glimmering, and is semitransparent. See CARNELIAN.

Agate.

The fossils known under this name are all compound substances; and hence cannot have a particular place in any systematic arrangement. Werner therefore has placed them as a supplement to the species chalcedony, which forms a principal constituent part of them, and disposes them according to their colour-delineations, thus: 1. Fortification agate; 2. Landscape agate; 3. Ribbon agate; 4. Moss agate; 5. Tube agate; 6. Clouded agate; 7. Land agate; 8. Star agate; 9. Fragment agate; 10. Punctated agate; 11. Petrifaction agate; 12. Coal agate; 13. Jasper agate. They are all compounded of chalcedony, carnelian, jasper, horn-stone, quartz, heliotrope, amethyst, indurated lithomarge, and opal, in different quantities and proportion; and are found in great abundance in Germany, France, England, Scotland, Ireland, and the East Indies.

The uses of agate are various. It is cut into vases, mortars, snuff-boxes, seals, handles to knives, and for many other useful purposes. See AGATE.

Twenty-sixth Species. Heliotrope.

The principal colour is intermediate between leek and dark celadon green, or mountain green. It occurs massive, and in angular as well as rolled pieces. Internally the lustre is glistening, and is always resinous. It is commonly translucent in the edges; is easily frangible, hard, and not particularly heavy.

Heliotrope is found in rocks belonging to the floetz trap formation, in Asia, Persia, Siberia, Saxony, and Iceland.

On account of its beautiful colour and its hardness, it is employed for nearly the same purposes as agate. See HELIOTROPE.

Twenty-seventh Species. Plasma.

The usual colour is intermediate between grass and leek-green, and of different degrees of intensity. It occurs in indeterminably angular pieces, which have a rough earthy crust. Internally its lustre is glistening. It is intermediate between semitransparent and strongly translucent, hard, brittle, frangible without great difficulty, and not particularly heavy.

Hitherto it has only been found among the ruins of Rome, and constituted a part of the ornamental dress of the ancient Romans.

Twenty-eighth Species. Chrysopras.

Its characteristic colour is apple-green, of all degrees of intensity. It is found massive in angular pieces, and in thick plates. Internally it is dull; the lustre intermediate between translucent and semitransparent. It is hard, not very difficultly frangible, nor particularly heavy; and is found along with quartz, opal, chalcedony, &c. at Kosemuctz, in Lower Silesia.

Chrysopras is principally used for ring-stones, and some varieties are highly esteemed; but it is difficult to cut and polish.

Twenty-ninth Species. Flinty Slate.

This has been divided into two sub-species, common flinty slate, and Lydian stone.

First Sub-species. Common Flinty Slate.

The principal colour is grey, but there are many varieties of shades. It occurs massive in whole beds, and frequently in blunt-angled pieces, with a smooth and glimmering surface. Internally, it is faintly glimmering; more or less translucent on the edges; hard, brittle, difficultly frangible, and not particularly heavy.

It occurs in beds in transitive mountains in Saxony, at the lead-hills in Scotland, and other places.

Second Sub-species. Lydian Stone.

The colour is greyish-black, passing into velvet-black. It occurs massive, and is frequently found in trapezoidal-shaped rolled pieces. Internally, it is glimmering; opaque, hard, pretty easily frangible, and not particularly heavy. It is found in similar formations with the preceding, near Prague and Carlsbad in Bohemia, in Saxony, and in the Moorfoot and Pentland hills, near Edinburgh.

When polished, it is used as a test-stone for determining the purity of gold and silver; but is less suited for this purpose than basalt, and some kind of clay slate.

Thirtieth Species. Cat's Eye.

The principal colour is grey, of which it presents many varieties. It occurs in blunt-edged pieces, in rolled pieces, and likewise massive. Internally, it is shining, usually translucent, and sometimes also semitransparent. It is hard, easily frangible, and not particularly heavy.

Its geognostic situation is unknown. It is imported from Ceylon and the coast of Malabar; and is usually cut for ring-stones. Some of the varieties are highly valued.

Thirty-first Species. Prehnite.

The colours are various shades of green, white, and yellow. It is sometimes massive, and sometimes crystallized in oblique four-sided tables. Externally, the crystals are smooth and shining; internally, inclining to glistening and pearly.

Prehnite is translucent, sometimes passing into semitransparent and transparent: it is hard, easily frangible, and not very heavy. It occurs in Dauphiny in veins of the oldest formation; in Scotland in rocks belonging to the newest floetz trap formation; and was first discovered in Africa by colonel Prehn, from whom it receives its appellation.

Thirty-second Species. Zeolite.

This species is divided by Werner into five sub-species. 1. Mealy zeolite; 2. Fibrous zeolite; 3. Radiated zeolite; 4. Foliated zeolite; 5. Cubec zeolite. As they are principally distinguished from each other by fracture, hardness, and lustre, we shall only observe, that the chief colours of all are yellowish, whitish, and reddish, with a variety of indeterminate shades; that zeolite occurs massive, in angular pieces, in balls, and sometimes chrystallized in short and oblique four-sided prisms, and in perfect smooth planed cubes; that it is according to the subspecies opaque, translucent, or even transparent; and that it is semi-hard, easily frangible, and not particularly heavy.

Zeolite occurs in rocks belonging to the newest formation, but is sometimes, though rarely, found in primitive green stone, either disseminated, in cotemporaneous balls, or lining or filling up air cavities or veins. All the different sub-species are natives of Scotland. The mealy zeolite is found in the Isle of Sky; the fibrons and radiated in the isles of Canary and Sky; the foliated in Staffa, and the cubic in the same isle, and likewise in Sky. They are likewise met with in Iceland, in Sweden, in Germany, and the East Indies. Figs. 13 and 14.

Thirty-third Species. Cross-Stone.

The colour is a greyish-white. It occurs chrystallized, either in broad rectangular four-sided prisms, or in twin chrystals. The chrystals are mostly small, and aggregated on one another. Both the internal and the external lustre is shining, inclining to splendent or glistening.

The cross-stone is translucent passing to transparent, semi-hard, easily frangible, and not particularly heavy. It has hitherto been found only in mineral veins, and in agate-balls, at Strontian, in Argyleshire, and at Andreasberg, in Hartz, as well as some other places.

Thirty fourth Species. Agate-Stone.

The colour is a perfect azure blue, of different shades. It is found massive, disseminated, and in rolled pieces. The lustre is glistening and glimmering. It is translucent on the edges, pretty hard, brittle, easily frangible, and not particularly heavy.

The geognostic situation is not correctly ascertained. It is said to have been found near the lake of Baikal, in Siberia, in a vein accompanied with garnet, felspar, and pyrites. It occurs in Persia, China, Tartary, and Siberia; in South America; but in Europe has only been found among the ruins of Rome.

Its beautiful colour renders it an object of attraction, and being capable of receiving a high polish, it is applied to various useful purposes, and enters into the composition of many different ornaments. It is the lapis lazuli of painters. Werner is constantly making additions to his species under every genus.

Of those belonging to the flint genus, which are less known, and have been described with less precision than the preceding, are coccolite, found in Sweden and Norway; pistazite, found in Norway, Bavaria and France; ceylanite, in Ceylon; enclase, in Peru; hyalite, near Franckfort; menilite, near Paris; lomonite, in Lower Britanny; natrolite, in Suabia; azurite, in Stiria, &c.; andalusite, or hardspar, in Saxony, France, and Spain; chiastolite, or hollow spar, in France and Spain, and probably in Cumberland; scapolite, in Norway; and arctizite, or wernerite, in Sweden, Norway, Switzerland, and lazulite.

FOURTH GENUS.

CLAY *Genus.*

First Species. Jasper.

This is divided into six sub species; Egyptian jasper, striped jasper, porcelain jasper, common jasper, agate jasper, and opal jasper.

Second Species. Opal.

Werner divides this into four sub-species, precious opal, common opal, semi-opal, and wood opal.

Third Species. Pitch-Stone.

The colours are black, green, brown, red, and occasionally grey. It occurs always massive in great beds and rocks. Internally its lustre is shining. It is commonly translucent in a small degree, brittle, and pretty easily frangible.

Pitch-stone is fusible without addition: occurs in beds in the newest porphyry and floetz trap formation; and is found in Saxony, Hungary, in several of the Hebrides, and in Dumfriesshire. Some of its varieties bear a striking resemblance to pitch, from whence it receives its appellation.

Fourth Species. Obsidian.

The principal colour is velvet-black. It always occurs in angularly roundish-pieces. Internally it is splendent. Some of the varieties are translucent, others semi-transparent. It is hard, easily frangible, and not very heavy.

Obsidian occurs insular in the newer porphyry formation, and is found in Hungary, Iceland, in Peru, and various other countries. When cut and polished, it is sometimes used for ornamental purposes, and mirrors for telescopes have been formed of it. It probably owes its origin to fire.

Fifth Species. Pearl Stone.

Its colour is generally grey, sometimes black and red. It occurs vesicular, and the vesicles are long and roundish, with a shining pearly lustre. It is translucent on the edges, not very brittle, very easily frangible, and rather light.

Pearl stone is found in beds of porphyry near Toka, in Hungary, in the north of Ireland, and the Hebrides.

Sixth Species. Pumice Stone.

Its usual colour is a light yellowish-grey passing into different neighbouring shades. It is small, and lengthened vesicular: its internal lustre glistening, generally translucent in the edges, soft, and seldom semi-hard, very brittle, easily frangible, and swims in fluids.

It occurs in various situations, generally accompanied by rocks that belong to the floetz trap formation; and though usually classed among volcanic productions, in some situations it evidently is of aquatic origin. It is found in the Lipari islands, in Hungary, Iceland, and on the banks of the Rhine; and is used for polishing stones, metals, glass, and ivory; and also for preparing parchment.

Seventh Species. Felspar

Is divided into four sub-species; compact felspar, common felspar, adularia, and Labradore stone. Fig. 15.

Eighth Species. Pure Clay

Is snow white, with occasionally a yellowish tinge, and occurs in kidney-shaped pieces, which have no lustre. It

is opaque, soils very little, adheres slightly to the tongue, is light, and intermediate between soft and friable.

Pure clay is found immediately under the soil, accompanied with foliated gypsum and selenite, at Halle, in Saxony, only.

Ninth species. Porcelain Earth.

The colour is generally a reddish-white, of various degrees of intensity. It occurs massive and disseminated; its particles are fine and dusty, slightly cohering, and feeling fine and light.

It is found in beds in gneiss, accompanied with quartz and other substances, in Saxony, at Passau, Limoges, and in Cornwall. In China and Japan, where it is called kaolin, it is very abundant. It forms the basis of china ware.

Tenth species. Common Clay.

This is divided into six sub-species, as follow:

1. Loam, of a yellowish-grey colour, frequently spotted with yellow and brown, and occurring massive. It is dull and weakly glimmering, colours a little, adheres pretty strongly to the tongue, and feels slightly greasy. It is often mixed with sand, gravel, and iron ochre.

2. Potter's clay is of two kinds, earthy and slaty. The earthy is of a yellowish and greyish-white colour in general; occurs massive; is opaque, colours a little, feels somewhat greasy, and adheres strongly to the tongue. Slaty potter's clay is generally of a dark ash-grey colour, and feels more greasy than the preceding. It occurs in great rock masses, and in alluvial land. Both kinds are universally distributed, and are of great importance in the arts and in domestic economy.

3. Pipe clay is greyish-white, passing into yellowish-white, occuring massive, of a glimmering lustre, and having its particles pretty coherent. It feels rather greasy, is easily frangible, and adheres pretty strongly to the tongue.

4. Variegated clay is commonly white, red, and yellow, striped, veined, and spotted. It occurs massive, is soft, passing into friable, feels a little greasy, and adheres somewhat to the tongue. It is found in Upper Lusatia.

5. Clay-stone is commonly grey, or red, with various intermediate tints. It occurs massive, is dull, opaque, soft, pretty easily frangible, feels rather meagre, and does not adhere to the tongue. It forms vast rock masses, occurs in beds and veins, and is found in Saxony, in Scotland, and in Shetland.

6. Slate clay is of a grey colour, presenting several varieties. It is massive, internally dull, opaque, pretty soft, mild, easily frangible, adheres a little to the tongue, and feels meagre. It is generally found wherever the oval, floetz trap, and alluvial formations occur.

Eleventh species. Polier, or Polishing-Stone,

Is of a yellowish-grey colour, striped, and the colours alternate in layers. It occurs massive, is dull, very soft, adheres to the tongue, feels fine but meagre, and is nearly swimming. It is found in the vicinity of pseudo-volcanoes, though hitherto it has only been discovered in Bohemia.

Twelfth species. Tripoli

Is of a yellowish-grey colour, passing into ash-grey; occurs massive, is internally dull, very soft, feels meagre and rough, does not adhere to the tongue, and is rather light. It is found in veins and beds in floetz rocks in Saxony, in Derbyshire, and many other countries besides Tripoli, from whence it was first brought. Its use in polishing metals and minerals is well known.

Thirteenth species. Alum-Stone

Is of a greyish-white colour, occurs massive, shows a tendency to chrystallization, is soft, passing to friable, and light. It is found at Tolfa, near Rome, from whence the famous Roman alum is manufactured.

Fourteenth species. Alum-Earth.

The colour is a blackish-brown, and brownish-black; it is massive, dull, feels a little meagre, and somewhat greasy; is intermediate between soft and friable, and light. It is found in beds of great magnitude in alluvial land, and in floetz trap formation in several parts of Germany, in Naples, and in France. It is lixiviated to obtain the alum it contains.

Fifteenth species. Alum-Slate

Is divided into two sub-species, as follow:

1. Common alum-slate is between a greyish and blueish-black colour, occurs massive, and in balls, is soft, not very brittle, easily frangible, and not very heavy.

2. Glossy alum-slate is of an intermediate colour, between bluish and iron-black; occurs massive, with a shining semi-metallic lustre, and in other respects resembles the former. It is found in beds and strata in Saxony, France, Scotland, and Hungary; and affords considerable quantities of alum.

Sixteenth species. Bituminous Shale

Is of a brownish-black colour, and occurs massive. Internally, its lustre is glimmering; it is very soft, rather mild, feels rather greasy, is easily frangible, and not particularly heavy.

It is found with clay-slate in the coal formation, in Bohemia, England, Scotland and other coal countries.

Seventeenth species. Drawing Slate, or Black Chalk.

Its colour is a greyish-black, with a tinge of blue; it occurs massive, is opaque, colours and writes, is soft, mild, easily frangible, feels meagre but fine, and is rather light.

It is found in primitive mountains in France, Germany, Iceland, Scotland, and the Hebrides. When of a middling degree of hardness, it is used for drawing.

Eighteenth species. Whet-Slate.

The common colour is greenish-grey; it is massive; internally, weakly glimmering, semi-hard, feels rather greasy, and is not particularly brittle or heavy. It occurs in primitive mountains in Saxony, Bohemia, and the Levant. When cut and polished, it is used for sharpening knives and tools.

Nineteenth species. Clay-Slate.

Its principal colour is grey, of which there are many varieties. It occurs massive; internally, its colour is glistening, the substance opaque, soft, pretty easily frangible. It is found in vast strata in primitive and transition mountains in many different countries, but particularly in Scotland. When split into thin and firm tables, it is used for roofing houses, and other purposes.

Twentieth species. Lepidolite.

Its colour is a kind of peach-blossom, red, verging on lilac-blue, and occurs massive. Its internal lustre, is glistening; it is translucent, soft, easily frangible, and

easily melts before the blowpipe. Hitherto it has only been found in Moravia, where it lies in gneiss.

Twenty-first species. Mica, or Glimmer.

Its common colour is grey, of great variety of shades. It occurs massive, disseminated in thin tables and layers in other stones, and chrystallized either in equilateral six-sided tables, or in six-sided prisms. The surface of the chrystals is splendent; internally, shining and splendent. In thin plates, it is transparent; but in larger masses only translucent on the edges. It is semi-hard, feels smooth, but not greasy, elastically flexible, and more or less easily frangible.

It forms one of the constituent parts of granite, gneiss, and mica slate, and is almost peculiar to the primitive mountains. It was formerly used instead of glass, for windows and lanterns. Fig. 16.

Twenty-second species. Pot-Stone.

Its colour is a greenish-grey, of different degrees of intensity; is massive; lustre, internally, glistening and pearly, translucent on the edges; soft, feels greasy, and is very difficultly frangible.

It occurs in beds, or is indular; and is found in the country of the Grisons, in Saxony, and probably in Hudson's-bay, and is nearly allied to indurated talc.

Twenty-third species. Chlorite,

Which see.

Twenty-fourth species. Hornblende,

Which see. See also fig. 17.

Twenty-fifth species. Basalt.

The usual colour is greyish-black, of various degrees of intensity. It occurs massive, in blunt and rolled pieces, and sometimes vesicular. Internally, it is commonly dull. It is usually found in distinct concretions, which are generally columnar, and sometimes upwards of 100 feet in length. Commonly opaque, semi-hard, brittle, very difficultly frangible, melts without addition, and is almost exclusively confined to the floetz trap formation. It occurs in strata, beds, and veins, in almost every quarter of the globe, and is very abundant in Scotland, Ireland, and in other parts of the British European dominions. It is useful for building, as a touch-stone, as a flux, and in glass manufactures.

Twenty-sixth species. Wacce.

The colour is a greenish-grey, of various degrees of intensity. It occurs massive and vesicular, is dull, somewhat glimmering, opaque, usually soft, more or less easily frangible, and not particularly heavy.

It is said to belong exclusively to the floetz trap formation, where it occurs in beds and above clay, and also in veins. It is found in Saxony, Bohemia, and Sweden.

Twenty-seventh species. Clink-Stone

Is commonly of a dark greenish-grey colour, always massive, and occurring in irregular columns, and tabular distinct concretions. It is usually translucent on the edges, brittle, easily frangible, and when struck with a hammer sounds like a piece of metal.

It is said to belong to the floetz trap formation, and generally rests on basalt. It is found in Lusatia, Bohemia, South America, and in the isle of Lambash, in the frith of Clyde.

Twenty-eighth species. Lava

Is divided into two sub-species.

1. Slag lava is of a greyish-black colour, passing into other shades. Externally, it is spotted, occurs vesicular and knotty, is generally opaque, semi-hard, brittle, easily frangible, and not particularly heavy.

2. Foam lava is of a dark greenish-grey colour, occurs small and fine, vesicular; externally, glimmering, slightly translucent on the edges, brittle, easily frangible, and light. It has often been confounded with pumice-stone, from which, however, it differs very much. On account of its lightness, it is used with advantage in arching vaults, and other kinds of building.

Twenty-ninth species. Green Earth.

Its colour is a celaden green, of various degrees of intensity. It occurs massive, in angular and globular pieces, and also disseminated. Internally, it is dull, streak glistening, very soft, easily frangible, and light.

It is principally found in an amygdaloid, in Saxony, Bohemia, Scotland, and other places, and is used by painters.

Thirtieth species. Lithomage

Is divided into two sub-species.

1. Friable lithomage, or rockmarrow, is snow-white, or yellowish-white, occurs massive, as a crust, and disseminated; is generally coherent, feels greasy and adheres to the tongue. Is found in tin veins, in Saxony.

2. Indurated lithomage is most commonly white, of which it presents several varieties; is massive, internally, dull; streak shining, very soft, easily frangible, feels greasy, and adheres strongly to the tongue. It occurs in veins of phorphyry, &c. in Saxony, Bohemia, Bavaria, &c.

Thirty-first species. Rock Soap

Is of a brownish or pitch-black colour, massive and disseminated, dull, opaque, does not soil, writes like drawing-slate, is easily frangible, and adheres strongly to the tongue.

It is found imbedded in rocks of the floetz trap formation, in Poland, and in the isle of Sky, but is very rare, and found only in small quantities.

Thirty-second species. Yellow Earth.

The colour is ochre-yellow, of different degrees or intensity; it is massive, streak somewhat shining, soils, writes, is very soft, adheres pretty strongly to the tongue, and feels somewhat greasy. It occurs in beds with ironstone, in Upper Saxony, and is employed as a pigment.

To the clay genus, likewise, belong adhesive slate, float-stone, pinite, and umber, which may be considered as recent discoveries.

FIFTH GENUS.

TALC *Genus.*

First species. Bole.

Its colour is cream-yellow, passing into various other shades; is commonly massive, very soft, easily frangible, feels greasy, gives a shining streak, adheres to the tongue, and is light. It occurs in rocks belonging to the newest floetz trap formation, and is found in beds of wacce or basalt, in Silesia, Italy, &c. It was formerly employed in medicine, but is now used only as a pigment.

Second species. Native Talc Earth.

The colour is yellowish-grey, passing into cream-yellow. It occurs massive, tuberose, and of other shapes; is internally dull, almost opaque, soft, frangible without much difficulty, and adheres a little to the tongue.

It is found in beds of serpentine, but only hitherto in Moravia.

Third species. Meerschaum.

The usual colour is yellowish-white. It occurs massive, is internally dull, opaque, streak shining, is soft, adheres strongly to the tongue, feels a little greasy, and is nearly swimming. It is principally found in Natolia, in Samos, Hungary, Moravia, Spain, and America. It is much used in the manufacture of heads of tobacco-pipes. It is said that the Turks eat it as a medicine.

Fourth species. Fuller's Earth.

The colours are greenish white, grey, olive, and oil-green. It is massive; internally dull, usually opaque, gives a shining streak, is very soft, feels greasy, and is not particularly heavy.

It is found in different situations in England, Saxony, Alsace, and Sweden; and is of essential use in cleansing wollen cloth, from which property it receives its name.

Fifth species. Neaphrite,

Which see.

Sixth species. Steatite.

The principal colour is white, of which it presents many varieties. It occurs massive, disseminated, in crusts, and chrystallized in six-sided prisms. Internally it is dull, streak shining, very soft, rather difficultly frangible, and feels greasy.

It is found in beds and veins in serpentine in Norway, Sweden, Saxony, England, Scotland, and China. It is used in the manufacture of porcelain, and for other purposes.

Seventh species. Serpentine,

Which see.

Eighth species. Schiller-Stone.

Its colour is olive-green, usually disseminated and massive; lustre shining, is soft, slightly brittle, and easily frangible. It occurs imbedded in serpentine, and is found in the Harz, in Saxony, Cornwall, and Ayrshire. It is often confounded with Labradore hornblende.

Ninth species. Talc.

This is divided into three sub-species.

1. Earthy talc is of an intermediate colour between greenish-white and light greenish-grey; friable, strongly glimmering, soils a little, feels rather greasy, and occurs in tin veins near Freyberg in Saxony.

2. Common, or Venetian talc, is principally of an apple-green colour, massive and disseminated, and in delicate and small tabular chrystals. It is almost always splendent and shining, translucent, in thin leaves transparent, flexible, but not elastic; soft, easily frangible, feels very greasy, and approaches to light.

It is almost wholly confined to the primitive mountains, where it is found imbedded in serpentine, and also in veins. It is found in the Tyrolese Alps, in Switzerland, and in Saxony.

3. Indurated talc is of a greenish-grey colour, of various degrees of intensity, occurs massive, is shining, passing to glistening, strongly translucent on the edges, soft, feels rather greasy, and is frangible without particular difficulty. It is found in primitive mountains in Tyrol, Austria, Scotland, and the Shetland isles.

Tenth species. Asbest.

See Asbestos.

Eleventh species. Cyanite,

Which see.

Twelfth species. Actynolite

Is divided into the following sub-species:

1. Asbestous actynolite is of a greenish-grey colour, occurs massive, disseminated, and in capillary chrystals; is internally glistening, translucent on the edges, soft, brittle, not easily frangible, nor particularly heavy. It is found in mineral beds in Saxony, and other parts of Germany.

2. Common actynolite is generally of a green leek-colour, passing into other shades of the same; it occurs massive, and likewise chrystallized in very oblique six-sided prisms, is splendent externally, semi-hard, rather brittle, and not easily frangible.

It is found in beds in primitive mountains, in Saxony, Switzerland, Norway, and Scotland.

3. Glassy actynolite is principally of a mountain-green colour, of various degrees of intensity; occurs massive, or in thin six-sided acicular chrystals, is shining and vitreous, strongly translucent, brittle, easily frangible, semi-hard, and is found in similar situations with the preceding.

Thirteenth species. Tremolite.

This is divided into the following sub-species:

1. Asbestous tremolite is of a whitish colour with a tinge of yellow, grey, red, or green: it occurs massive, and in capillary and acicular chrystals; internally glistening, very soft, easily frangible, and translucent on the edges.

2. Common tremolite is nearly of the same colour as the preceding, occurs massive, and in long and very oblique four-sided prisms: internally, is shining and glistening, translucent and semi-transparent, semi-hard, and pretty easily frangible.

3. Glassy tremolite is yellowish, reddish, greyish, and greenish-white; occurs massive, and chrystallized. Internally, is shining and pearly; is composed of very thin prismatic concretions, which are again collected into very thick prismatic concretions. It is translucent, brittle, and pretty easily frangible, and is said to emit a phosphoric light when rubbed in the dark.

Tremolite is principally found imbedded in primitive mountains, particularly the mountains of Tremola, in Switzerland. It is also found in different parts of Germany, and in Scotland.

Sahlite, lately discovered in Sweden, likewise belongs to the talc genus.

SIXTH GENUS.

Calc *Genus.*

First species. Rock Milk.

Its colour is yellowish-white; it is composed of dully, dusty particles generally weakly cohering, feels meagre yet fine, soils very much, and is very light. It is found in fissures and holes of mountains composed of floetz lime-stone, in Switzerland.

Second species. Chalk.

Its colour is principally all yellowish-white: it occurs massive, disseminated, and as crust over flint. Internally, is dull, opaque, soils, writes, soft, sometimes very soft, very easily frangible, feels meagre, and rather rough; effervesses strongly with acids, and is found principally on the sea-coast, though the Chiltern range in England

is wholly composed of it. It is used for polishing and cleansing metals, glass, &c. and in some places as a manure, and cement in building.

Third species. Lime-Stone

Is divided into several sub-species:

1. Compact lime-stone is of two varieties, common compact lime-stone, and roe-stone. The former is generally of a grey colour, but is frequently veined, zoned, striped, or clouded; occurs massive, and in rolled pieces; is translucent on the edges, semi-hard, brittle, pretty easily frangible; is almost entirely confined, like lime in general, to the floetz mountains; occurs in sand, stone, and coal formations, in England, Scotland, and many other countries; and is frequently used for building or making roads, or, when burnt, for manure and cement.

The latter, or roe-stone, is of a chesnut brown colour, is massive; internally dull, composed of small and fine-grained globular distinct concretions; semi-hard, brittle, not very easily frangible; occurs in beds in considerable quantities in Saxony, and is solely used for manure, for which its admixture with marl admirably fits it.

2. Foliated limestone is likewise of two kinds, granular limestone, and calc spar (figs. 18. and 19.). The former is commonly whitish, but presents many varieties of that colour; is massive, occurs almost always in granular distinct concretions, is more or less translucent, semi-hard, brittle, easily frangible, is peculiar to the primitive and transitive mountains, and is chiefly found in Italy, whence it is distributed over Europe, for the purpose of statuary. The white marble of Paros, or granular limestone, has long been celebrated. Scotland furnishes some beautiful varieties of marbles, whose uses are well known.

The latter, or calc spar, is principally white, but has many shades. It occurs massive, disseminated, and chrystallized, either in six-sided prisms, or three-sided prisms. The lustre alternates from splendent to shining and glistening, and is most commonly vitreous. The massive varieties are translucent, and sometimes even transparent. It is found veinigenous in almost every rock from granite to the newest floetz trap, occurs in a great variety of mineral veins, and is very universally disseminated. but is found particularly beautiful in Derbyshire, in Ireland, Saxony, France, and Spain.

3. Fibrous limestone, is of two varieties, common fibrous limestone, and fibrous limestone, or calc sinter. The former is commonly greyish, reddish, or yellowish-white; massive, lustre glistening, fragments splintery, more or less translucent, semi-hard, and occurs only in small veins.

The latter, or calc sinter, is principally white, of which it exhibits several beautiful varieties; occurs massive, and also in many particular external forms; internally is glimmering and pearly. It is commonly found in curved lamellar distinct concretions, is more or less translucent, semi-hard, brittle, and easily frangible; it is discovered in almost every limestone country. The grotto of Antiparos, and similar situations, afford striking instances of calc sinter. It is the alabaster of the ancients, and is still used in statuary.

4. Pea-stone is commonly yellowish-white, massive, internally dull, opaque or translucent on the edges; soft, very easily frangible; and is found in great masses in the vicinity of the hot springs at Carlsbad in Bohemia. It is composed of spherically round distinct concretions. All the varieties of limestone effervesce with acids.

Fourth species. Schaum, or foaming earth,

Is principally of a light yellowish colour; occurs massive and disseminated; is intermediate between shining and glistening; presents large, coarse, small, and fine-grained distinct concretions; is generally opaque, soft, completely friable, feels fine, but not greasy, and cracks a little. It is found in cavities of the oldest floetz limestone in Thuringia, and in the north of Ireland.

Fifth species. Slate spar.

Its colour milky, and greenish or reddish-white; occurs massive; lustre intermediate between shining and glistening, and completely pearly; fragments slaty, stranslucent, soft, and pretty easily frangible. It is found in limestone-beds in primitive mountains, and is produced in Norway, Saxony, and Cornwall.

Sixth species. Brown spar.

This is divided into the following sub-species:

1. Foliated brown spar, is principally white and red, with several varieties of each. It occurs massive, globular, with tabular impressions, and frequently chrystallized, externally shining, internally alternating from shining to splendent. It is found in granular distinct concretions of all magnitudes; is more or less translucent, semihard; a little difficultly frangible, and occurs in veins generally accompanied with calc spar, &c. in the mines of Norway, France, Germany, England, and other countries.

2. Fibrous brown spar is of a flesh-red, passing into rose-red; occurs massive, lustre glistening, fragments splintery, in other respects resembling the preceding. Hitherto it has been found only in Hungary and Transylvania.

Seventh species. Rhomb spar.

Its colours are yellowish and greyish-white; occurs only in regular middle-sized rhombs; lustre splendent, generally intermediate between translucent and semi-transparent; is semihard, brittle, easily frangible, and is found imbedded in rocks belonging to the talc genus in Switzerland, Sweden, and on the banks of Loch-lomond in Scotland.

Eighth species. Schaalstone.

The most common colour is greyish-white; it occurs massive, is shining and nearly pearly, translucent, pretty hard, brittle, easily frangible, and has been hitherto found only in the Bannat of Tameswar, accompanied by copper ore.

Ninth species. Stink-stone.

Its colour is wood-brown, passing into various other shades. It occurs massive, and sometimes disseminated through gyps, is dull or glimmering internally, translucent on the edges, rather soft, easily frangible, and when rubbed, emits an urinous smell. It is found in considerable quantities in the district of Mansfield in Thuringia.

Tenth species. Marle,

Which see.

Eleventh species. Bituminous marle slate.

Its colour is intermediate between greyish and brownish-black; it is massive, from glimmering to shining, fragments slaty, unusually soft, not very brittle, easily frangible, and streak shining. It is found in beds along with the oldest floetz lime-stone, and contains much cop-

per intermixed with it, on account of which it is usually smelted in Thuringia.

Twelfth species. Calc tuff.

The colour is yellowish-grey; it is generally perforated or marked with the impressions of other substances, also amorphous, ramose, and corroded. Internally dull, substance opaque, soft, easily frangible, and approaching to swimming. It occurs in alluvial land, and is found in Thuringia, at Gotha, and other places in Germany.

Thirteenth species. Arragone.

The principal colours are greenish-grey, and iron-grey. It occurs chrystallized in perfect equiangular six-sided prisms; the luster is glistening, passing into shining, and is vitreous; it is semi-hard, brittle, not particularly heavy, and plurplurresces a little. It was first discovered in the province of Arragon, whence its name, imbedded in gyps, but has since been found in some other countries of the continent.

Fourteenth species. Appatite.

The usual colours are white, green, blue, and red; it generally occurs chrystallized, the radical form of which is the equiangular six-sided prism. Externally it is splendent, internally shining and resinous. It is commonly transparent, semi-hard, brittle, easily frangible, and occurs in tin veins in Saxony, Bohemia, and in Cornwall. It has been confounded with schorl, &c. Fig. 20.

Fifteenth species. Asparagus or spargel stone.

The principal colour is asparagus-green; it occurs only chrystallized in equiangular six-sided prisms, is internally shining, most frequently translucent, semi-hard, easily frangible, and brittle. Hitherto it has been found only in Murcia in Spain, though supposed to be produced in Norway. It is nearly allied to appatite. Fig. 21.

Sixteenth species. Boracite.

Its colours are yellowish, smoke and greyish-white, passing to asparagus-green; it occurs in chrystallized cubes, with the edges and angles truncated, internally shining, commonly semi-transparent, semi-hard, brittle, and easily frangible. Hitherto it has been discovered only at Luneburg in Hanover. Fig. 22.

Seventeenth species. Fluor,

Which see, also fig. 23.

Eighteenth species. Gyps.

This is divided into the following sub-species:

1. Gyps earth is of a yellowish-white colour, passing into some allied shades, is intermediate between fine scaly and dusky, dull and feebly glimmering, soils a little, feels meagre but soft and fine, and is light. It is found, though rarely, in gyps countries, and is formed in the same manner as rock milk. It is used as a manure.

2. Compact gyps, is commonly ash-grey, passing into smoke and yellowish-grey, is massive, internally dull, feebly translucent on the edges, very soft, frangible without great difficulty, and is employed in architecture and sculpture, under the name of alabaster.

3. Foliated gyps is commonly white, grey, or red, presenting spotted, striped, and veined colour delineations. It occurs massive, and in blunt-edged pieces, but seldom in chrystals. Internally it alternates from shining and glistening to glimmering, is translucent and duplicating, very soft, and not particularly difficultly frangible. It has been confounded with granular limestone.

4. Fibrous gyps is principally white, grey, and red, with various shades of each. It occurs massive and dentiform, the internal lustre is usually glistening and pearly, commonly semi-transparent and translucent, very soft, and easily frangible.

Fossils belonging to the gyps formation, occupy different situations. They are found in Switzerland, Thuringia, Derbyshire, Cornwall, Moffat in Scotland, and other places.

Gyps, when burnt, forms an excellent cement, and is used for many ornamental purposes.

Nineteenth species. Selenite.

Its principal colour is snow-white, passing into other neighbouring shades: is generally massive, but not unfrequently chrystallized in pretty oblique six-sided prisms, the chrystals seldom large, but internally shining and splendent. Fig. 24.

Selenite is completely transparent, soft, somewhat flexible, not very frangible, and is found in the oldest gyps formation, in single chrystals in clay beds in the newest formation, and in other situations. It is common in Thuringia, at Montmartre near Paris, Shotover near Oxford, and in the isle of Sheppy. It is employed in taking the most delicate impressions, for crayons and other purposes.

Twentieth species. Cube spar.

The colour is milk-white with various allied shades. It is massive, occurring in large, coarse, and small ground distinct concretions. The lustre is shining, passing into splendent, translucent, softish, very easily frangible, and not particularly heavy. It is found in salt rocks in Salzbourg.

To the calc genus are also referred phosphorite, which forms a great bed in the Estremadura in Spain; and the anhydrite, found in the duchy of Wirtemberg.

SEVENTH GENUS.

BARYTE *Genus.*

First species. Witherite.

Is commonly of a light yellowish-grey colour, generally massive, but sometimes chrystallized in six-sided prisms, or double six-sided pyramids. The lustre of the principal fracture is shining; the fragments generally wedge-shaped. It is translucent, somewhat semihard, brittle, easily frangible, and pretty heavy. Figs. 25 and 26.

It melts, without addition, before the blowpipe, into a white enamel, and occurs in veins along with heavy spar, lead-glance, &c. at Anglesark in Lancashire. Combined with muriatic acid, it may be used in medicine, though a very active poison of itself.

Second species. Heavy spar or baryte.

See BARYTES.

EIGHTH GENUS.

STRONTIAN *genus.*

First species. Strontian.

The usual colour is intermediate between asparagus and apple-green; it occurs most commonly massive, but sometimes chrystallized in a circular six-sided prism. The crystals are scopiformly and manipularly aggregated. The lustre of the principal fracture is shining, of the cross fracture glistening. It is translucent in a greater or less degree, soft and semi-hard, brittle, easily frangible, dissolves in acids with effervescence, and occurs along

with lead-glance, heavy spar, &c. at Strontian in Argyleshire, the only place where it has yet been found.

Second species. Celestine

Is divided into two sub-species:

1. Fibrous celestine, is of an intermediate colour, between indigo-blue and blueish-grey; it occurs massive and in plates, and also chrystallized, showing a tendency to prismatic distinct concretions; is translucent, soft or semi-hard, easily frangible, and pretty heavy. It is found in Pennsylvania and in France.

2. Foliated celestine, is of a milky-white colour, falling into blue; it occurs massive, and also chrystallized in six-sided tables intersecting each other. It has a glistening lustre, is strongly translucent, softish, not particularly brittle, easily frangible, and hard. It occurs sometimes in sulphur beds, and is found very finely chrystallized in Sicily, and likewise near Bristol. Fig. 27.

CLASS II.

Fossil Salts.

The substances included in this class are confined to those which are found in a natural state only; and the greater part of them appear to be formed by the agency of water, air, &c.

The distinguishing characters of fossil salts are, their taste and easy solution. They resemble each other so closely, that the term *saline consistence* is used to express whatever relates to hardness, tenacity, and frangibility.

First species. Natron, or Natural Soda.

It may be divided into the two following sub-species:

1. Common natron, is of a yellowish or greyish-white colour, occurs in fine flakes or in dusty particles, has a sharp alkaline taste, effervesces with nitric acid, is easily soluble in water, and strikes blue vegetable tinctures green. It occurs as an efflorescence in the surface of the soil, or on the sides and bottoms of lakes that occasionally become dry. It is found in very large quantities in Hungary, Bohemia, and Egypt; and in many other countries of the Old World.

2. Radiated natron, or natural soda, is of a greyish or yellowish-white colour, occurs in crusts or chrystallized in capillary or acicular crystals, is glistening and translucent, and is found in large quantities in the province of Sukana in Barbary, and Southern Africa.

Natron is principally employed in the manufacture of glass, soap, and for washing. It is also used as a flux after being purified.

Second species. Natural nitre.

The colour is greyish or yellowish-white, approaching to snow-white; it is flaky, sometimes verges to solid and massive, is of a saline consistence, and tastes saltly cooling. Placed on hot iron, it hisses and detonates; is usually found in thin crusts on the surface of the soil at particular seasons of the year, particularly in hot climates. It is also met with in various countries of Europe, and is much used in making gunpowder, in medicine, and the arts. The greatest part, however, employed for those purposes, is an artificial preparation from the refuse of animal and vegetable bodies undergoing putrefaction, and mixed with calcareous and other earth.

Third species. Natural Rock-salt

Is divided into two sub-species:

1. Rock or stone salt, which is of two kinds, foliated or fibrous. The former is commonly of a white or grey colour, occurs massive and disseminated; and also crystallized in cubes; in general is trongly translucent, rather hard, easily frangible, and feels somewhat greasy. The latter is greyish, yellowish, and snow-white; occurs massive, is strongly translucent, verging to semitransparent, decrepitates when laid on burning coals, and is found in beds lying over the first or oldest floetz trap formation. It forms whole hills at Codova in Spain, is found also in Germany, and almost every country in the world. At Nantwich in Cheshire it has long been dug. Its use is as general as its dissemination. It is employed as a daily seasoning for our food, as a manure, in various manufactures, and for purposes too numerous to mention.

2. Lake-salt occurs either in thin plates, which are formed on the surface of salt-lakes, or in grains at their bottom. It is translucent, and of a saline consistence. It is found in Cyprus, near the Caspian sea, and in various parts of Africa.

Fourth species. Natural sal ammoniac.

The colour is commonly greyish or yellowish-white. It is of a saline consistence, and is flaky, with an urinous taste. It is sometimes found massive, stalactitic, tuberose, botryoidal, and chrystallized. It is the product of volcanoes and pseudo-volcanoes, and is found in Italy, Sicily, in the vicinity of inflamed beds of coal both in England and Scotland, and in several countries of Asia.

Fifth species. Natural Epsom salt.

Colour a greyish-white. It occurs in capillary efflorescences, and is mealy or flaky, of a saline consistence, and tastes saltly bitter. It is found as an efflorescence on clayey stones or gyps rocks, at Sena, at Solfatara, in Hungary, and Bohemia. It is also contained in many mineral springs, particularly those of Epsom, whence it derives its name. Epsom salts are much used as an easy purgative. Considerable quantities of magnesia may be obtained from them.

Sixth species. Natural Glauber salt.

The colour is usually greyish and yellowish-white. It occurs in the form of mealy efflorescences, in crusts, and sometimes crystallized in acicular and six-sided prismatic chrystals. Internally it is shining, with a vitreous lustre, is soft, brittle, easily frangible, and has a cooling but saltly bitter taste.

It is found on the borders of salt-lakes, on moorish ground, on old and new-built walls in different countries of Europe, Asia, and Africa, and is used as a purgative medicine, and in some places as a substitute for soda in the manufacture of white glass.

Seventh species. Natural alum

Is of a yellowish or greyish-white colour; occurs as a mealy efflorescence, or in delicate capillary crystals; has a sweetish astringent taste, and is produced in various situations in Scotland, Germany, Italy, Spain, Sweden, and in Egypt.

Alum is employed as a mordant in dyeing, and in the manufacture of leather, as a medicine, for preventing wood from catching fire, and for preserving animal substances from putrefaction.

Eighth species. Hair salt.

The principal colours are snow, yellowish, and greyish-white. It occurs in delicate capillary crystals, has a saline consistence, and a sweetish astringent taste.

Hair salt is found in different mine countries on the con-

tinent, at Whitehaven in England, and near Paisley in Scotland, and bears a striking resemblance to fibrous gyps.

Ninth species. Rock butter.

The colour is light-yellow or greyish-white. It occurs massive and tuberose, is translucent, has a saline consistence, or sweetish-sour astringent taste, and feels a little greasy. It oozes out of fissures of rocks of alum slate, and is found in Lusatia, Thuringia, Denmark, Siberia, and near Paisley in Scotland.

Tenth species. Natural vitriol

Is divided into the three following sub-species:

1. Iron vitriol, is commonly of an emerald and verdigris green. It occurs massive, tuberose, stalactitic, and chrystallized in different figures; is splendent and vitreous, has a saline consistence, and a sourish astringent taste. It is found usually along with iron pyrites, by the decomposition of which it is formed, in different countries of continental Europe, in many of the English mines, and in America. It is employed to dye linen yellow, and wool and silk black, in the preparation of ink, as a paint, &c.

2. Copper vitriol, is usually of a dark sky-blue colour. It occurs massive, disseminated, stalactitic, dentiform, and chrystallized; is translucent, soft, very brittle, and has a styptic taste. It is found in various mining countries, in Wicklow, and in Anglesea. It is used in cotton and linen printing, and when prepared is employed by painters.

3. Zinc vitriol, is of a greyish, yellowish, reddish, and greenish-white colour. It occurs tuberose, stalactitic, and coralloidal, is translucent, of a saline consistence, and a styptic taste. It is produced most abundantly where much blend occurs, and is found in Austria, Hungary, and Sweden.

Here it must be remarked, that borax, though so well known by name, is without a place in the Wernerian system, as it is uncertain whether or not it occurs in a solid state. It is most probable that it occurs only in solution in certain lakes. See Borax.

The new genus stallite, of which only one species, cryolite, has been found in Greenland, seems properly to come under this head.

CLASS III.

Inflammable Fossils.

Fossils belonging to this class are light, brittle, mostly opaque, yellow, brown, or black, seldom chrystallized, and never feel cold. They are more nearly allied to the metallic than to the earthy or saline classes.

First Genus.

Sulphur *Genus.*

First species. Natural sulphur.

It contains the two following sub-species:

1. Common natural sulphur, is of the colour the name expresses, but of different degrees of intensity. It occurs massive, disseminated, and chrystallized in octahedrons or double six-sided pyramids, is internally between shining and glistening, translucent, in chrystals frequently transparent, very soft, easily frangible, and light.

It is found in masses in gyps, in veins that traverse primitive rocks, in nests of lime-stone, and in other situations, and is produced in every quarter of the world, though in the British dominions it seems to be confined to Ireland.

2. Volcanic natural sulphur is of the colour the name imports, but with a considerable tinge of green. It ocurs corroded, vesicular, perforated, amorphous, and sometimes as a sublimate in flowers, is glistening and resinous, and translucent in a slight degree. It is found only in volcanic countries and among lava, but is produced in great abundance; and is employed in medicine, in the composition of gunpowder, and as a vapour in whitening wool and silk.

Second Genus.

Bituminous *Genus.* See Bitumens.

First species. Brown Coal. See Coal.

Fourth Genus.

Graphite *Genus.*

First species. Glance coal.

This is divided into two sub-species.

1. Conchoidal glance coal, is of an iron-black colour, of different degrees of intensity, occurs massive and vesicular, internally shining, bordering sometimes on semihard, brittle, easily frangible, and light. It burns without flame or smell, and has hitherto been found only in the newest floetz mass formation, accompanied with other kinds of coal, at Meissner in Hessia. The fracture is conchoidal.

2. Slaty glance coal, is of a dark iron-black colour, occurs massive, is shining and glistening, soft, very essily frangible, light, and intermediate between sectile and brittle. It is found imbeded in masses, beds, and veins, in primitive, transitive, and floetz rocks, and is produced in Spain, Savoy, Saxony, Bohemia, and in the isle of Arran in Scotland. Its principal fracture is more or less slaty.

Second species. Graphite.

This contains two sub-species:

1. Scaly graphite, is commonly of a dark steel-grey colour. It occurs massive and disseminated, is usually glistening, fracture scaly-foliated, is very soft, perfectly sectile, writes and soils, feels very greasy, and is rather difficultly frangible.

2. Compact graphite, is rather blacker than the preceding, is internally glimmering with a metallic lustre, fracture fine-grained, in other respects agreeing with the preceding. It usually occurs in beds, and is found near Keswick in England, in Ayrshire in Scotland, and in various other parts of Europe, Asia, and Africa. The finer kinds are first boiled in oil, and then cut into pencils. The coarser parts and sawings are melted with sulphur, and then cast into coarse pencils for the use of artificers. It is likewise applied to various other purposes, under the vulgor name of black lead.

Third species. Mineral charcoal.

The colour is a greyish-black. It occurs in small angular and somewhat cubical-shaped, pieces, is glimmering, with a silky lustre, soils strongly, is soft, and light. It is found in thin layers in different kinds of coal, and is widely disseminated.

Fifth Genus.

Resin *Genus.* See Resins.

First species. Amber.

This is divided into the two following sub-species:

1. White amber, is of a straw-yellowish colour It oc-

curs massive, and sometimes associated with the following sub-species, is glistening with a resinous lustre, fracture conchoidal, and simply translucent.

2. Yellow amber, is of a wax-yellow colour, passing into several neighbouring shades. It occurs always in indeterminately angular blunt-edged pieces, is externally dull, internally splendent, with a vitreous and resinous lustre. It is transparent, soft. rather brittle, pretty easily frangible, light, and swimming. It burns with a yellow-coloured flame, emiting an agreeable odour; when rubbed, it acquires a strong negative electrical virtue; is found in layers of bituminous wood, and in moor coal, on sandy sea-shores, and frequently floating on the sea. It is chiefly produced on the coast of Prussia, in Sweden, Norway, &c. and according to some, has been found in the alluvial land near London. [It is also frequently met with in the alluvial soil of New Jersey.] It admits of a fine polish, and is cut into necklaces, bracelets, snuff-boxes, and various other articles. The oil and acid obtained from it are used in medicine.

Second species. Honey-stone.
See Mellite.

CLASS IV.

Metallic Foffils.

First, Platina *Genus.*

First species. Native platina.

The colour is very light steel-grey, approaching to silver-white. It occurs in flat, smooth, and smallish grains, externally shining, lustre metallic, intermediate between semi-hard and soft, completely malleable, pretty flexible, and very heavy, its specific gravity being about 15.6.

Platina is the least fusible of metals, and does not amalgamate with mercury. It has hitherto been found only in sand accompanied with other metals, and is produced in South America, and probably also in St. Domingo and Barbadoes. From the peculiar qualities it possesses of resisting the action of many salts, of remaining unaltered in the air, and of receiving a fine polish, it has been rendered subservient to several purposes in chemistry and the arts. See Platina.

Second Genus. *Gold.*

First species. Native gold.

This is divided into three sub-species:

1. Gold-yellow native gold, is of a perfect colour, corresponding to its name. It seldom occurs massive, often disseminated in membranes, in roundish and flattish pieces, in grains, and also chrystallized in cubes, octahedrons, simple three-sided pyramids, garnet dodecahedrons, and acute double eight-sided pyramids. External lustre of the chrystals is splendent; internally it is glimmering, passing into glistening. It is soft, completely malleable, flexile, and uncommonly heavy. It is found in veins, beds, disseminated in rocks, and in grains, in almost every country of the world, but commonly in too small quantities to be collected for use. America and Africa supply the largest quantities.

2. Brass-yellow native gold, is principally of the colour of brass, occurs disseminated, capillary, moss-like, reticulated, and in leaves, also chrystallized in thin six-sided cubes, and is rather lighter than the preceding. It is found in different situations in Bohemia, Transylvania, and Norway.

3. Greyish-yellow native gold, is of a brass-yellow colour falling into steel-grey, occurs in very small flattish grains like platina, and is found with that metal.

Third Genus. *Mercury*, which see.

First species. Native mercury, or quicksilver.

The colour is tin-white; it occurs perfectly fluid in globules, is splendent, and has a metallic lustre, does not wet, feels very cold, and is uncommonly heavy. Before the blow-pipe it is volatilized, without any smell. It is usually found in cinnabar at Idria. It occurs in a compact limestone, and here it is very abundant. It is likewise produced in different parts of Germany, France, Spain, and in very large quantities in Peru.

The uses of quicksilver are multifarious, and cannot be enumerated in this place.

Second species. Native amalgam.

Fluid or semi-fluid amalgam is of an intermediate colour between tin and silver-white. It occurs in small massive pieces and in balls, also disseminated and chrystallized in different forms. Externally it is shining and splendent, is soft and somewhat fluid; when cut or pressed, it emits a creaking sound like common amalgam, and is uncommonly heavy.

Third species. Mercurial horn-ore, or corneous mercury,

Is of an ash-grey colour, of various degrees of intensity; occurs very rarely massive, but commonly in small vesicles, internally chrystallized and splendent. It is soft, sectile, easily frangible, and heavy. It is usually found with the other species of mercury, and is produced in the same countries. It was first discovered in the mines of the Palatinate.

Fourth species. Mercurial liver-ore, or mercurial hepatic-ore.

Compact mercurial liver-ore, is of an intermediate colour between dark-red and lead-grey, occurs massive, is glistening and glimmering internally, opaque, soft, sectile, easily frangible, and uncommonly heavy. It is the most common ore of mercury at Friaul in Idria.

Fifth species. Cinnabar.

Dark-red cinnabar, is principally of a perfect cochineal red, occurs massive, disseminated, in blunt-cornered pieces, in membranes, amorphous, dendritic, fruticose, and chrystallized. The chrystals are small, splendent externally, and shining internally. The massive cinnabar is opaque or translucent on the edges, very soft, sectile, easily frangible, and uncommonly heavy.

Bright-red cinnabar is of a lively scarlet-red colour. It occurs massive and disseminated, is internally glimmering, substance opaque, streak shining, soils, is very soft, sectile, very easily frangible, and very heavy. Both belong to the same countries with quicksilver. In Idria, Spain, and Peru, this genus is most abundant. It does not occur in Norway, Sweden, Great Britain, or Ireland. From the ore of cinnabar the greatest part of the mercury used in commerce is obtained.

Fourth Genus. *Silver.*

First species. Native Silver.

Common native silver is of the colour the name expresses. It occurs massive, disseminated, in pieces, plates, and membranes, as well as in other forms, besides being chrystallized in cubes, octahedrons, four-sided rectangu-

lar prisms, double six-sided pyramids, double three-sided pyramids, and hollow four-sided pyramids. It is soft, perfectly malleable, common flexible, and very heavy when pure. It appears to belong to the newer primitive rocks, where it occurs in veins, and is usually accompanied with heavy spar and quartz.

Second species. Antimonial silver.

The colour is intermediate between tin-white and silver-white. It occurs massive, disseminated, and chrystallized, is externally glistening, internally shining and splendent with a metallic lustre. It is found in coarse, small, and fine granular distinct concretions, is sectile, not very difficultly frangible, soft, and uncommonly heavy. It contains upwards of 80 parts of silver. It occurs in veins composed of calx, spar, &c. in Spain, Germany, and other countries.

Third species. Arsenical silver.

The colour is tin-white, passing into silver-white. It occurs massive, disseminated, globular, and chrystallized; is softish, sectile, and very heavy. It contains about 12 parts of silver, much arsenic and iron, and is usually found with native arsenic and other minerals in Germany and Spain, but is a rare mineral.

Fourth species. Corneous silver-ore, or horn-ore.

The colour is most frequently a pearl-grey, of all degrees of intensity. It occurs massive, disseminated, in membranes, balls, and also chrystallized in cubes and in acicular and capillary chrystals. It is more or less translucent, soft, perfectly malleable, and heavy. It contains upwards of 60 parts of silver, and is found always in veins. It is widely distributed over the globe, but is most abundant in South America. It is sometimes found in Cornwall, and receives its name from cutting like horn.

Fifth species. Silver-black.

The colour is a bluеish-black, whence its name. It occurs massive, disseminated, and in various other forms, of all degrees of consistence, from friable to solid. It gives a shining metallic streak, soils very little, is easily frangible, sectile, and heavy. It is found with silver-glance and horn-ore in Hungary, Bohemia, Norway, and Siberia.

Sixth species. Silver-glance

Is of a dark-blackish lead-grey colour, occurs usually massive, disseminated, in membranes, &c. and also chrystallized in cubes, octahedrons, garnet dodecahedrons, and double eight-sided pyramids. Externally it is shining and glistening; internally it alternates from shining to glistening, and has a metallic lustre. It is soft, completely malleable, pretty flexible, and uncommonly heavy, containing upwards of 80 parts of pure silver; and is found in veins, along with native silver and other minerals, in Hungary, Austria, and other countries of Europe, but more particularly in Mexico and Peru.

Seventh species. Brittle silver-glance.

The colour is intermediate between iron-black and dark lead-grey. It occurs massive, disseminated, in membranes, and frequently chrystallized in equiangular six-sided prisms, and rectangular four-sided tables. Externally it is highly splendent, internally shining and glistening. It is soft, brittle, easily frangible, and uncommonly heavy, containing upwards of 60 parts of silver. It is found always in veins, accompanied with other minerals, and principally in Hungary and Saxony.

Eighth species. Red silver-ore.

Dark-red silver-ore is intermediate between cochineal red and lead-grey. It occurs massive, disseminated, dendritic, in membranes, and chrystallized in equiangular six-sided prisms. It is externally splendent; internally it alternates from shining to glimmering. The massive varieties are opaque; the chrystallized passing from semi to transparent. It is soft, sectile, easily frangible, and heavy.

This species occurs always in veins, accompanied with other minerals, and is found in Bohemia, Hungary, Norway, and other countries.

Ninth species. White silver-ore.

The colour is a very light lead-grey. It occurs massive and disseminated, has a metallic lustre, a shining streak, is soft, slightly flexible, easily frangible, and heavy. It contains large quantities of lead, sulphur, and antimony, and scarcely 10 parts of silver. It is always found in veins, and chiefly near Freyberg.

Tenth species. Black silver-ore.

The principal colour is iron-black, inclining to steel-grey. It occurs massive, disseminated, and chrystallized in three-sided pyramids. Internally it is shining with a metallic lustre. It is semi-hard, sectile, easily frangible, and heavy.

FIFTH GENUS. *Copper,* which see.

First species. Native copper.

The colour is copper-red, but frequently tarnished. It occurs massive, disseminated, and in various other forms, besides being chrystallized in cubes, dodecahedrons, &c. It is intermediate between semi-hard and soft, completely malleable, common flexible, difficultly frangible, and very heavy. It is usually found in veins and sometimes in beds, and is produced in Cornwall, Anglesea, the Shetland islands, and many other countries of Europe, Asia, and America. Copper may be applied to a vast number of useful purposes, and is next to iron the most necessary of metals.

Second species. Copper-glance.

Compact copper-glance is usually of a dark lead-colour, passing into blackish-grey. It occurs massive, disseminated, in membranes, and occasionally chrystallized; externally shining, internally between shining and glistening. It is soft, perfectly sectile, easily frangible, and heavy.

Third species. Variegated copper-ore.

Its colour, when dug, is intermediate between copper-red and pinchbeck-brown, but it soon becomes tarnished. It occurs massive, disseminated in plates, membranes, and chrystallized in octahedrons. It is soft, slightly sectile, easily frangible, and heavy; and is found in beds, veins, and rocks of different formations, in Cornwall, and various parts of continental Europe. It yields about 70 parts of pure copper.

Fourth species. Copper-pyrites.

When fresh, its colour is brass-yellow, of different shades according to its richness. It occurs massive, disseminated in membranes, &c. and also chrystallized in various figures. Externally it is intermediate between glistening and shining, internally soft; is between semi-hard and soft, brittle, easily frangible, and heavy.

Fifth species. White copper-ore

Is of an intermediate colour between silver-white and

bronze-yellow: occurs massive and disseminated; is internally glistening, with a metallic lustre; rather soft, brittle, easily frangible, and heavy. It is found in veins and mineral beds in primitive mountains, and is produced in Cornwall, in different parts of Germany, in Siberia, and in South America; but it is one of the rarest species of copper-ore.

Sixth species. Grey copper-ore, or Fahl-ore.

The most common colour is steel-grey: it occurs massive, disseminated, and also chrystallized in tetrahedrons. octahedrons, and garnet dodecahedrons. It is more or less semi-hard, brittle, easily frangible, and heavy; and is found in the newer primitive rocks, and likewise in transitive and floetz rocks, in several mines of Cornwall, in Germany, Italy, Sweden, Norway, Siberia, and Chili. It is usually smelted on account of the copper it contains.

Seventh species. Copper-black.

The colour is usually intermediate between blueish and brownish-black: it occurs massive, or disseminated, and as a coating, to other ores of copper; is always more or less cohering, and heavy, containing from 40 to 50 parts of copper. It is usually found with copper pyrites, &c. and is produced in Silesia, Germany, France, Sweden, Norway, and Siberia. Sometimes it is very beautiful.

Eighth species. Red copper-ore.

Compact red copper is usually of a dark cochineal-red colour: occurs massive, in membranes, crowded, amorphous, and also disseminated. Internally it is glimmering, inclining to glistening, with a semi-metallic lustre: it is opaque, semi-hard, brittle, easily frangible, and heavy.

Ninth species. Tile-ore.

Earthy tile ore is usually of a red hyacinth colour; massive, disseminated, and incrusting copper pyrites; is intermediate between friable and solid, soils slightly, is almost always coherent, and is heavy. It is found in veins, commonly accompanied with native copper ore and malachite.

Tenth species. Copper azure.

Earthy copper azure is of a smalt-blue colour; usually friable, and disseminated; is composed of dusty particles, does not soil, is chiefly cohering, and approaches to heavy. It is found in small quantities, usually accompanied with malachite and copper green, in different parts of Germany, in Norway, and Siberia.

Eleventh species. Malachite, which see.

Twelfth species. Copper green.

The principal colour is verdigris-green, of different degrees of intensity: it usually occurs massive, disseminated, and coating malachite; is internally shining; more or less translucent, soft, not very brittle, easily frangible, and intermediate between heavy and not particularly heavy. It is found in the same geognostic situation with malachite, in Cornwall and other countries, but is rare.

Thirteenth species. Iron-shot copper green.

Earthy iron-shot copper green is usually of an olive-green colour: occurs massive, and disseminated; is dull, soils a little, soft, passing into friable, not very brittle, easily frangible, and not particularly heavy.

Fourteenth species. Copper emerald.

The colour is an emerald-green. It occurs in chrystallized six-sided prisms, which are externally and internally shining, with a vitreous lustre, and translucent. It is semi-hard, brittle, and not particularly heavy; and is found in the remoter parts of the Russian dominions, and on the Chinese frontiers.

Fifteenth species. Copper mica

Is usally of an emerald-green colour: it occurs massive, disseminated, and occasionally chrystallized in very thin six-sided tables. Externally it is smooth and splendent, internally splendent with a pearly lustre. The massive varieties are translucent; the chrystallized transparent. It is soft, sectile, not very brittle, nor particularly heavy; and has hitherto been found only in veins in Cornwall, where it passes under the unscientific name of foliatic arseniat of copper.

Sixteenth species. Lenticular-ore.

The colour is sky-blue, sometimes passing into verdigris-green. It occurs chrystallized in small, flat, double, four-sided pyramids; is externally shining; translucent, soft, rather brittle, and very easily frangible. Hitherto it has been found only in Cornwall.

Seventeenth species. Oliven-ore.

Foliated oliven ore is of a perfect olive-green: seldom occurs massive, usually in drusy crusts, and in small chrystals, presenting acute rhomboids, and oblique four-sided prisms. Internally it is glistening, with an adamantine lustre. It is very soft, sectile, and heavy in a low degree; and has hitherto been found only in Cornwall.

Sixth Genus. *Iron.*

First species. Native iron

Is of a light steel-grey colour, inclining to silver white: it has hitherto been found only ramose; internally it is intermediate between glimmering and glistening, with a perfect metallic lustre, and a hackly fracture. It is between soft and semi-hard, perfectly malleable, common flexible, difficulty frangible, and uncommonly heavy. Hitherto it has been found only in loose masses on the surface of the earth, and is a rare production.

Second species. Iron pyrites.

Common iron pyrites is usually of a perfect bronze-yellow colour: it occurs massive, disseminated, in membranes, and also chrystallized in cubes, octahedrons, dodecahedrons, icosahedrons, and leuzite chrystals. It is hard, brittle, and heavy, and when rubbed or struck with steel, emits a strong sulphureous smell. It occurs in almost every kind of mineral repository, but most commonly in granite: its geographic distribution is equally extensive, but it is principally valued on account of the sulphur which may be extracted from it by sublimation.

Third species. Magnetic pyrites

Is of an intermediate colour between bronze-yellow and copper-red: it occurs massive and disseminated; is internally shining, with a metallic lustre, passes from hard to semi-hard, is brittle, easily frangible, and heavy. It is attracted by the magnet; is found only in primitive mountains, in Caernarvonshire, in several parts of Germany, in Norway, and Siberia; and is used for the same purposes as common pyrites.

Fourth species Magnetic iron-stone.

Common magnetic iron-stone is of an iron-black colour: is massive, disseminated, and also chrystallized in cubes, octahedrons, and garnet dodecahedrons, and rectangular four-sided prisms. It is externally shining; internally between splendent and glistening, with a metallic lustre: is intermediate between hard and semi-hard, brittle, and heavy. It occurs most frequently in primitive mountains, and is found in the Shetlands, many parts

of Germany, and other countries, particularly Sweden. When pure it affords excellent bar iron.

Fifth species. Iron glance.

Common iron glance is usually of a dark steel-grey colour, with several different shades. It commonly occurs massive and disseminated, and also chrystallized in flat, double, three-sided pyramids, and in double three-sided pyramids. Externally it alternates from splendent to glistening; internally it is most commonly glistening. It is hard, brittle, heavy, and rather difficultly frangible. It occurs in beds and veins in primitive and transitive mountains, and is found in considerable quantities in Sweden and other countries, and affords, when smelted, an excellent malleable iron.

Sixth species. Red iron-stone.

Red iron froth. The colour is intermediate between cherry-red and brownish-red. It occurs commonly friable, massive, sometimes coating and disseminated, and is composed of scaly particles, which are glimmering, and have a semi-metallic lustre. It soils strongly, feels greasy, and is pretty heavy. It is found usually in veins, and chiefly in primitive mountains in Lancashire, Cornwall, Norway, Germany, and Chili, and produces good iron.

Seventh species. Brown iron-stone.

Brown iron froth is of an intermediate colour between steel-grey and clove-brown, and is between friable and solid. It occurs massive, coating, spumous, &c. and is composed of scaly particles, shining and glistening, with a metallic lustre. It soils strongly, feels greasy, and is very light. It is commonly found lining drusy cavities, in brown hematite, in the Shetland isles, in various parts of Germany, and in Chili.

Eighth species. Sparry iron-stone.

The principal colour is a light yellowish-grey, which, on exposure to the air or heat, changes into brown or black. It occurs massive, disseminated, with pyramidal impressions, in plates, and chrystallized. It is found in granular distinct concretions, commonly translucent on the edges, semi-hard, not very brittle, easily frangible, and heavy. It is chiefly confined to the primitive and floetz mountains, and is produced in small quantities in England, Scotland, and Ireland; but on the continent it is in some places very abundant, and affords an iron which is excellently adapted for steel-making.

Ninth species. Black-stone.

Compact black iron-stone, is of an intermediate colour between bluish-black, and dark steel-grey: it occurs massive, tuberose, reniform, &c. is semi-hard, brittle, easily frangible, and heavy.

Tenth species. Clay iron-stone.

Reddle is of a light brownish-red, passing into cherry-red: it occurs only massive; soils strongly, and writes, is sectile, easily frangible, and rather heavy. It is chiefly found in the newer clay-slate, and is produced pretty abundantly in Germany and Siberia. The coarser varieties are used by the carpenter, the finer by the painter, under the name of red-chalk.

Eleventh species. Bog iron-ore.

Morass ore is of a yellow-brown colour, sometimes friable, sometimes coherent, and occurs massive, corroded, in grains, and tuberose. It soils pretty strongly, feels meagre but fine, and is lightish.

Twelfth species. Blue iron-earth.

When fresh it is whitish, but soon becomes of an indigo-blue colour, of different degrees of intensity; it occurs massive, disseminated, and thinly coating; the particles are dull and dusty; it soils slightly, feels fine, and is lightish. It is found in nests in clay-beds, and other situations, in the Shetland isles, Iceland, Sweden, and Siberia. [This mineral is found in indurated masses, some of which are susceptible of a very fine polish, in the neighbourhood of Allenstown, New Jersey.]

Thirteenth species. Green iron-earth.

Friable green iron-earth is of a siskin-green colour, occurs massive and disseminated, is more or less cohering, soft, fine, easily frangible, and intermediate between particularly heavy and heavy.

Fourteenth species. Cube-ore.

The colour is olive-green, of different degrees of intensity, it occurs massive, and chrystallized in small cubes, is translucent, soft, brittle, and not particular heavy. It is found in veins, but hitherto only in Cornwall.

SEVENTH GENUS. *Lead.*

First species. Lead glance.

Common lead glance is of a fresh lead-grey colour, of different degrees of intensity; it occurs massive, disseminated, in membranes, &c. and also chrystallized in cubes, octahedrons, four-sided prisms, six-sided prisms, and three-sided tables. It is soft, sectile, externally easily frangible, and uncommonly heavy; and is found in veins and beds in primitive, transitive, and floetz mountains, at lead-hills in Lanarkshire, Derbyshire, and several other counties of England, Scotland, and Wales; besides being widely diffused over other parts of the globe. It is most frequently worked as an ore of lead, but sometimes as an ore of silver.

Second species. Blue lead-ore.

It is of an intermediate colour between dark indigo-blue and lead-grey; it occurs massive, and chrystallized in perfect siz-sided prisms, is soft, sectile, easily frangible, and heavy, and is found in veins with other minerals of the same class, but is altogether a rare fossil, nor has it hitherto been discovered in Britain.

Third species. Brown lead-ore

Is of a hair-brown colour of different degrees of intensity, it occurs massive, and chrystallized in six-sided prisms, is feebly translucent, soft, not very brittle, easily frangible, and intermediate between heavy and uncommonly heavy. It is found in veins, accompanied with other minerals, in Bohemia, Hungary, Brittany, and Saxony.

Fourth species. Black lead-ore.

The colour is greyish-black, of different degrees of intensity; it occurs massive, disseminated, and chrystallized in six-sided prisms; externally is usually splendent, internally shining with an adamantine lustre, is rather brittle, easily frangible, and heavy. It is found in veins, and almost always accompanied with other kinds of lead-ore, at lead-hills in Scotland, in Bohemia, Saxony, and other mineral countries.

Fifth species. White lead-ore.

The colour is white, but has various shades; it occurs massive, disseminated, in membranes, but most commonly chrystallized in prisms and pyramids, of different

figures. Externally, it is specular splendent; internally between splendent and glistening, with an adamantine lustre. It is soft, brittle, very easily frangible, and heavy, and is found in most places where the other species occur, in England, Wales, Scotland, Ireland, &c. Next to lead glance it is the most common of the lead ores, but is seldom in sufficient abundance to become an object to the metallurgist.

Sixth species. Green lead-ore.

Its colour is grass-green, of various shades; it generally occurs chrystallized, in six-sided prisms, is always translucent, soft, rather brittle, very easily frangible, and heavy. It is produced in Scotland and other countries, and is sometimes confounded with the preceding species.

Seventh species. Red lead-ore.

Its general colour is a hyacinth-red; it occurs massive but rarely, sometimes in membranes, but most commonly chrystallized in broad oblique four-sided prisms, is both externally and internally splendent, very soft, between brittle and sectile, easily frangible, and heavy. It is found in veins in gneiss and mica slate, accompanied with other fossils of the same kind, in Austria, Savoy, and Siberia, and on account of its beautiful colour is chiefly used as a pigment.

Eighth species. Yellow lead-ore.

Its principal colour is wax-yellow; it is generally chrystallized in rectangular four-sided tables, cubes, octahedrons, equiangular eight-sided tables, and double eight-sided pyramids. Externally, it is shining and smooth, internally glistening, with a resinous lustre; it is translucent, soft, between brittle and sectile, easily frangible, and heavy. It is found in compact lime-stone in Carinthia, and some other countries of the continent.

Ninth species. Lead vitriol, or vitriol of lead.

The colour is yellowish-grey and greyish-white; it occurs only chrystallized in octahedrons of different figures. Externally it is shining, internally splendent, with an adamantine lustre. It is often semi-transparent; rather brittle, and heavy, and is found in Scotland, Anglesea, and Spain.

Tenth species. Lead earth.

Coherent lead earth is usually of a yellowish-grey colour; it occurs massive, is internally glimmering, usually opaque, soft, inclining to sectile, easily frangible, and heavy. It is found in primitive lime-stone in Derbyshire. Scotland, and many other countries.

EIGHTH GENUS. *Tin.*

First species. Tin pyrites.

The colour is intermediate between steel-grey and brass-yellow; it occurs massive and disseminated. Internally is glistening, and has a metallic lustre, is semi-hard, brittle, easily frangible, and heavy. It melts easily, and has hitherto been found only in Cornwall.

Second species. Tin-stone.

The most common colour is blackish-brown; it occurs massive, disseminated, in rolled pieces, and grains, like sand, but most frequently chrystallized in prisms and pyramids of different figures. Internally it is shining and glistening, it yields a greyish-white streak, is hard, easily frangible, brittle, and very heavy. It is found only in primitive rocks, and is confined to a few situations, like all the tin genus.

Third species. Cornish tin-ore, or wood tin.

The most usual colour is hair-brown, of different degrees of intensity; it occurs usually in rolled pieces, sometimes reniform with impressions. It is found usually in large and coarse granular distinct concretions, is opaque, hard, brittle, easily frangible, and uncommonly heavy. It is infusible, and hitherto has only been found in Cornwall in alluvial land, accompanied with tin stone.

NINTH GENUS. *Bismuth.*

First species. Native bismuth.

Its colour is silver-white, with an inclination to red; it occurs massive, disseminated in leaves, reticulated, and chrystallized in small four-sided tables, and in small and indistinct cubes, and three-sided pyramids. It is soft, sectile, and rather difficultly frangible, and uncommonly heavy; and is found in veins in primitive mountains in Saxony, and other parts of the continent; but is doubtful if produced in Britain. [It has been recently discovered in Connecticut.]

Second species. Bismuth-glance.

The colour is a light lead-grey; it occurs massive, disseminated, and in circular and capillary chrystals; it soils, inclines to sectile, is easily frangible, and heavy. It is found always in veins, and is usually accompanied with native bismuth, chiefly in Saxony, Bohemia, and Hungary.

Third species. Bismuth-ochre.

The colour is a straw-yellow, passing into other neighbouring shades; it is massive and disseminated, opaque, soft, not very brittle, easily frangible, and heavy. This mineral is rare, and seems to be confined to a few places in Saxony and Bohemia.

TENTH GENUS. *Zinc.*

First species. Blende.

Yellow blende is of a dark wax and sulphur-yellow colour; it usually occurs massive and disseminated, but is sometimes chrystallized in rectangular four-sided prisms; it is shining and splendent both externally and internally, with an adamantine lustre; is found in large and coarse granular distinct concretions, is usually translucent, semi-hard, brittle, easily frangible, and heavy. It phosphoresces when rubbed in the dark; occurs most frequently in transitive mountains in Bohemia, and other parts of Germany.

Second species. Calamine.

The general colour is yellowish-grey, which passes into other neighbouring shades; it occurs massive, disseminated, cellular, corroded, &c. and chrystallized in tables, cubes, pyramids, and prisms. Externally the chrystals are splendent and shining; internally, between shining and glimmering. It is usually found in small and fine granular distinct concretions, is semi-hard, not very brittle, rather difficulty frangible, and heavy; and is produced in beds in a floetz limestone formation, accompanied with iron-ochre, lead-glance, &c. It is met with in all the mine countries of England and Scotland, in Germany, and other parts of the continent; and when purified and roasted, is used for the fabrication of brass, which is a compound of zinc and copper.

[A red oxyd of zinc has been lately discovered in Sussex county, New-Jersey, by Dr. Archibald Bruce. It occurs abundantly in several of the iron mines of Sussex; and in the manufacture of brass possesses advantages

over the ores generally used for that purpose. See BRUCE'S JOURNAL, p. 96.]

ELEVENTH GENUS. *Antimony.*

First species. Native antimony.

The colour is perfect tin-white: it occurs massive, disseminated, reniform, and probably chrystallized; in the fresh fracture it is splendent, and has a metallic lustre. It is found usually in coarse, small, and fine granular distinct concretions, is soft, sectile, easily frangible, and heavy in a low degree. It is produced in veins in Dauphiny and in the Harz, and disseminated in calx-spar in Westermanriland, in Sweden; but is a rare mineral.

Second species. Grey antimony-ore.

Compact grey antimony-ore is usually of a light lead-grey colour, occurs massive, disseminated, and occasionally in membranes; internally is shining and glistening with a metallic lustre, is soft, not very heavy, easily frangible, soils, and becomes more shining in the streak. It is found in Sweden and some other countries, but is the rarest sub-species.

Third species. Black antimony-ore

Is of an iron-black colour, occurs only chrystallized in rectangular four-sided tables, is internally shining with a metallic lustre; is soft, rather sectile, and heavy. In Cornwall it is found of peculiar beauty.

Fourth species. Red antimony-ore.

Its colour is cherry-red; it occurs massive, often in membranes, but most frequently in delicate capillary chrystals; both externally and internally it is shining, and has an adamantine lustre. It is found in coarse, small, and longish granular distinct concretions, is opaque, not very brittle, and easily frangible; but is a very rare species.

Fifth species. White antimony-ore.

It passes in colour from snow-white to several neighbouring shades; occurs massive and in membranes occasionally, but most commonly chrystallized in rectangular four-sided tables, cubes, and acicular and capillary chrystals. It is found in coarse and small granular distinct concretions, is translucent, soft, rather sectile and heavy. Before the blowpipe, it becomes wholly volatilized. It is found in veins in Bohemia, Hungary, and Saxony.

Sixth species. Antimony-ochre.

The colour is a straw yellow, of various degrees of intensity; it seldom occurs massive and disseminated, but usually as a coating on chrystals of grey antimony ore. It is dull, soft, not very brittle, nor particularly heavy. It is found always in veins, in different parts of Germany, and is evidently found by the decomposition of grey antimony ore.

TWELFTH GENUS. *Cobalt.*

First species. White cobalt-ore.

When fresh fractured the colour is usually tin-white; it occurs massive, disseminated, &c. and also chrystallized in cubes and double four-sided pyramids. It is found in coarse, small, and fine granular distinct concretions; is semi-hard, brittle, not very difficultly frangible, and heavy. It easily melts before the blowpipe, emits a strong arsenical smell, and yields a white metallic globule. It usually occurs in beds in primitive mountains, and is found in Sweden, Norway, and Silesia.

Second species. Grey cobalt-ore.

On the fresh fracture its colour is light steel-grey inclining to white, but it becomes tarnished by exposure; it occurs only massive, disseminated, tubiform and specular; internally it is glimmering or glistening, with a metallic lustre, is found in thick and curved lamellar distinct concretions, and is produced in Cornwall, Norway, and various other countries.

Third species. Cobalt-glance.

The colour is a silver-white, slightly inclining to reddish: it is commonly massive and disseminated, sometimes chrystallized in different forms; is externally splendent, internally between shining and glistening, and has a metallic lustre. It is semi-hard, brittle, not very easily frangible; and when struck with steel, emits an arsenical smell. It is found in veins in various formations, in the different mine countries of the continent of Europe; and from it the greatest part of the cobalt in commerce is obtained, which is highly useful in the manufacture of glass, and as a paint.

Fourth species. Black cobalt-ore.

Earthy black cobalt ore is of an intermediate colour between brownish and blueish-black, is composed of dull, dusky particles, which soil a little, usually cohering, streak shining, and very light.

Fifth species. Brown cobalt-ochre

Is of a liver-brown colour, passing sometimes into other neighbouring shades; it occurs massive and disseminated, is internally dull, soft, sectile, easily frangible, and light; and appears to be peculiar to the floetz mountains in some parts of Germany and Spain.

Sixth species. Yellow cobalt-ochre.

Is usually of a dirty straw-yellow, occurs massive, frequently much bursten and corroded; it is internally dull, streak shining, soft, and rather friable, sectile, easily frangible, and light. It is the rarest species of cobalt ore, but most valued on account of its purity.

Seventh species. Red cobalt-ochre.

Cobalt crust is of a peach blossom-red colour, of different degrees of intensity, occurs most frequently in velvety drusy coatings, and disseminated, is feebly glimmering, bordering on dull, scarcely soils, has a shining streak, and is very soft and light.

THIRTEENTH GENUS. *Nickel.*

First species. Copper-nickel.

Is of a red copper-colour of different degrees of intensity; it occurs usually massive and disseminated, is internally glistening, and has a metallic lustre. It is usually unseparated; sometimes, however, it is found in coarse and small granular distinct concretions, is semi-hard in a high degree, brittle, not very easily frangible, and heavy. Before the blowpipe it emits an arsenical smell and odour, and afterwards melts, though with difficulty. It is found in Cornwall, Norway, and many other countries, and is nearly allied to cobalt.

Second species. Nickel-ochre

Is of an apple-green colour, occurs always as a coating or efflorescence, is composed of dull dusty particles, loose, or little cohering, feels meagre, and is light. It is found in the same situations with the preceding species. It is not certain that native nickel has yet been discovered, though it is mentioned by some mineralogists.

FOURTEENTH GENUS. *Manganese.*

First species. Grey manganese-ore.

Radiated grey manganese ore is of a dark steel-grey colour, occurs massive, disseminated, and chrystaliized in prisms of different varieties. It is found in coarse, large, and small granular, distinct concretions; soils strongly when rubbed, is soft, brittle, rather difficultly frangible, and not particularly heavy. It is produced in several counties of England and Scotland, and in different parts of Germany.

Second species. Black manganese-ore.

Is of an intermediate colour between brownish-black and dark greyish-black, occurs massive, disseminated, and in octahedral chrystals. It is found in small and fine granular concretions; is opaque, semi-hard, brittle, and heavy; but is a rare mineral, and hitherto found only in a few places of Germany and Spain.

Third species. Red manganese-ore

Is of a light rose-red colour, occurs massive and disseminated, is internally dull, translucent in a slight degree, hard, brittle, easily frangible, and heavy. It is found in veins in Norway, France, and some other countries.

FIFTEENTH GENUS. *Molybdena.*

First species. Molybdena.

Its colour is a fresh burning lead-grey; it occurs usually massive and disseminated, but also chrystallized in six-sided tables, and short six-sided prisms; internally it is splendent, the fracture perfectly foliated, and is found in large and coarse granular distinct concretions. It soils a little, is very soft, easily frangible, its thin leaves common flexible, sectile, feels greasy, and is heavy. It is one of the oldest of metals, and occurs only in primitive mountains, disseminated, or in veins; and is produced in Norway, Sweden, Bohemia, and other countries.

SIXTEENTH GENUS. *Arsenic.*

First species. Native arsenic.

When fresh broken it is of a light whitish lead-grey colour, but it speedily tarnishes: it occurs massive, disseminated, reniform in plates, with various impressions. It is found in thin, curved, lamellar, distinct concretions; in the streak it becomes shining and metallic, semi-hard in a high degree, very easily frangible, and between sectile and malleable. It occurs only in primitive mountains, and in veins of a newer formation, and is found in various parts of Germany, in France, and in Chili.

Second species. Arsenic pyrites.

Common arsenic pyrites is, when fresh, of a silver-white colour, but soon acquires a yellowish tarnish; it occurs massive, disseminated, and also in chrystals of various figures. Internally, it is shining, with a metallic lustre; and is found usually unseparated, is hard, brittle, not easily frangible, and heavy. It occurs only in primitive mountains and in beds, and is produced in Norway, Germany, and Siberia. From this ore the white oxide of arsenic is principally obtained.

Third species. Orpiment.

Red orpiment is of an aurora-colour, of different degrees of intensity: it occurs massive, disseminated in membranes, and also chrystallized in oblique four-sided and six-sided prisms. It is translucent, but the chrystals are transparent, is very soft, yields a lemon or orange-coloured streak, and is easily frangible. It is found both in primitive and floetz montains, and is produced in Germany, France, Italy, and the West Indies. It is used as a pigment.

Yellow orpiment is of a perfect lemon-yellow colour, occurs massive, and in very minute chrystals, is found in large, coarse, and small angular granulated distinct concretions, is translucent, very soft, sectile, and common flexible. It occurs principally in floetz mountains, and in several parts of Germany and the East.

Fourth species. Arsenic-bloom.

The colour is a reddish-white and snow-white; it occurs as a coating, in small balls, &c. and in very delicate capillary shining chrystals, is translucent on the edges, very soft, easily frangible, and soils. It is produced in rents of a granite rock, and hitherto has only been discovered in Swabia.

SEVENTEENTH GENUS. *Scheele.**

First species. Tungsten.

The colour is usually yellowish and greyish-white, which pass into several other neighbouring shades; it occurs massive, disseminated, and frequently chrystallized. Internally it is shining, with a vitreous lustre; is more or less translucent, soft, not very brittle, and uncommonly heavy. It is found in primitive mountains, and belongs to the oldest metalliferous formations, and is produced in Cornwall, Sweden, Saxony, and Bohemia.

Second species. Wolfram

Is of an intermediate colour between dark greyish-black, and brownish-black; it occurs massive, and also chrystallized in broad six-sided prisms, and rectangular four-sided tables; and is found in fortification-wise curved lamellar distinct concretions. It is opaque, yields a reddish-brown streak, is soft, brittle, and uncommonly heavy. It is produced in the primitive mountains, almost always accompanied with tin, in Cornwall, and some other countries.

EIGHTEENTH GENUS. *Menachine.*

First species. Menachanite

Is of a greyish-black colour, inclining to iron-black, occurs only in small flattish angular grains. Internally is glistening, with an adamantine lustre, is perfectly opaque, soft, brittle, retains its colour in the streak, is easily frangible, and moderately heavy. It is attractable by the magnet, and is found in Cornwall, accompanied by fine quartz-sand, in the isle of Providence in America, and at Botany Bay.

Second species. Octrahedrite.

Its colour passes from indigo-blue to many other shades; it occurs only chrystallized, and that in very acute octahedrons. It is chiefly translucent, and semi-transparent, semi-hard, brittle, and borders on heavy. It is found in Dauphiny, and appears from accurate experiments to be an oxide of menachine mixed with silica.

Third species. Rutile

Is of a dark blood-red colour, of various degrees of intensity; it occurs always chrystallized in four-sided and six-sided prisms, and also in compressed acicular and capillary chrystals. Externally it is shining, internally splendent, translucent in a slight degree, hardish, easily frangible, and not very heavy. It is found imbedded in drusy cavities of granite, &c. in different parts of Germany,

* So called in honour of the illustrious Scheele.

France, Spain, Siberia, and South Carolina, [and imbedded in primitive limestone in Chester county, Pennsylvania.]

Fourth species. Nigrine

Is of a dark brownish-black colour, passing to velvet-black; it occurs in larger and smaller angular grains, and in rolled pieces. Externally moderately glittering, internally the same, with an adamantine lustre, is opaque, semi-hard, brittle, and yields a yellowish-brown streak. It is found in alluvial hills in several parts of Germany, and also in Ceylon.

Fifth species. Iserine

Is of an iron-black colour, somewhat inclining to brownish-black; it occurs usually in small obtuse angular grains, and in rolled pieces, internally glistening, with a semi-metallic lustre, is completely opaque, hard, brittle, and retains its colour in the streak. Hitherto it has been found only in the stream called Iser in Germany, from which it receives its appellation. It bears a great resemblance to iron-sand.

NINETEENTH GENUS. *Uran.*

First species. Pitch-ore

Is usually of a velvet-black colour; it occurs almost always massive and disseminated. Internally is shining, soft, brittle, uncommonly heavy, and completely infusible without addition. It is found in veins of primitive mountains along with lead and silver ores, and is produced in Saxony and Norway.

Second species. Uran mica.

The principal colour is a grass-green, passing into various allied shades; it occurs sometimes in membranes, but commonly chrystallized in rectangular four-sided tables. The fracture is foliated, the fragments and distint concretions are too minute to be determined. It is more or less translucent, soft, sectile, easily frangible, and is found in iron-stone veins in Corwall, Saxony, and France.

Third species. Uran Ochre.

Friable uran ochre is usually of a straw-yellow colour: it generally occurs as a coating or efflorescence on pitch-ore; is friable, and composed of dull dusty particles, which feel meagre, and are not particularly heavy.

Indurated uran-ore is of the same colour as the preceding: occurs massive and disseminated, is generally dull, internally opaque, soft, brittle, and soils a little, and is found along with the other ores of uran.

TWENTIETH GENUS. *Sylvan.*

First species. Native Sylvan

Is of an intermediate colour between white and silver-white: occurs massive and disseminated, and also chrystallized in four and six-sided prisms, and in small three-sided pyramids, in cubes, and in short acicular chrystals. It is soft, not very brittle, easily frangible, and heavy; and before the blowpipe melts as easily as lead, burning with a light green colour, and emitting a sharp, disagreeable odour. Hitherto it has only been found at Face-bay, in Transylvania.

Second species. Graphic-ore.

Its colour is a light steel-grey: it occurs massive and chrystallized; externally is splendent, internally glistening. When massive, it shows a tendency to fine granular concretions: it is soft, brittle, sectile, and heavy, and is worked as an ore of gold in Transylvania, where alone it has yet been found.

Third species. Yellow Sylvan-Ore

Is of a silver-white colour, inclining to brass-yellow: it occurs disseminated and chrystallized in very small and rather broad four-sided prisms; is soft, rather sectile, and uncommonly heavy. It is found along with the other species of the genus, and contains a considerable portion both of gold and silver.

Fourth species. Black Sylvan-Ore

Is an intermediate colour between iron-black and blackish lead-grey: it occurs massive, and in small, thin, and longish six-sided tables, which are usually imbedded. Externally it is splendent; internally shining, soils a little, is very soft, sectile, splits easily, and in thin leaves is common flexible. It melts easily before the blowpipe; occurs in veins along with other minerals, but is only found in Transylvania, where it is worked for the gold and silver it contains.

TWENTY-FIRST GENUS. *Chrome.*

First Species. Acicular or Needle-ore.

Its colour is dark steel-grey: occurs in imbedded acicular chrystals: internally shines with a metallic lustre, is soft, not very brittle, heavy, and is always accompanied with chrome ochre, and sometimes with native gold. It is found in Siberia.

Second Species. Chrome Ochre

Is of a verdigris-green, passing through several neighbouring shades: it occurs massive, disseminated, and in membranes; is dull, soft, not very heavy, and is found with the preceding species.

Having already extended this article to a greater length than was intended, in order that we might be able to give a satisfactory view of the beautiful system of Werner, we shall only subjoin the names of some other minerals, which either have not been regularly classed, or are but recently discovered, and therefore have not been accurately investigated: these are

Earthy fossils, foliated prehnite, schmelzstein, spodumene, meionite, somnite, glassy felspar, spinthere, metallic fossils, pitchy iron ore, gadolinite, copper sand or muriate of copper, phosphat of copper, corneous lead ore, reniform lead ore, bournonite, columbite, tantalite, yttertantalite.

To which may be added loisite, needle or acicular-stone, fish eye-stone, iron-clay, figure-stone, granular actynolite, dolomite, foliated celestine and it varieties, silver black with its sub-species.

EXPLANATION OF PLATE II.

FIG. 1. The Icosahedron.
2. The Dodecahedron.
The Hexahedron, as
3. Cube.
4. Rhomb.
5. Rectangular tetrahedral prism.
6. Oblique-angular tetrahedral prism.
7. Oblique-angular tetrahedral prism, in which the terminal planes are set obliquely on the lateral planes.
8. Equiangular hexahedral prism.
9. Tetrahedron, or simple three-sided pyramid.
10. Double three-sided pyramid, in which the lateral planes of the one pyramid are set on the lateral edges of the other.

11. Octahedron.
12. Simple six-sided pyramid.
13. Double six-sided pyramid, in which the lateral planes of the one pyramid are set on the lateral planes of the other.
14. Double six-sided pyramid, in which the planes of the one pyramid are set obliquely on those of the other, so that the common base forms a zig-zag line.
15. Rectangular four-sided table.
16. Oblique-angular four-sided table.
17. Equiagular six-sided table.
18. Lengthened six-sided table.
19. and 20. Common lens.

Alteration of the Fundamental Figures by Truncation.

21. Cube truncated on all its angles.
22. Cube truncated on all its edges.

By Bevelment.

23. The cube bevelled on all its edges.
24. Three-sided prism having its lateral edges bevelled.
25. Oblique-angular four-sided prism bevelled on its extremities.
26. Six-sided table, with bevelled terminal planes.
27. Octahedron, with bevelled angles.

By Acumination.

28. Cube, with the angles acuminated by three planes which are set on the lateral plates.
29. Cube, with the angles acuminated by three planes which are set on the lateral edges.
30. Rectangular four-sided prism acuminated by four planes, which are set on the lateral planes.
31. Equiangular six-sided prism, acuminated on both extremities by six planes, which are set on the lateral planes.
32. Four-sided prism, acuminated on both extremities by four planes, which are set on the lateral edges.
33. Six-sided prism, acuminated on both extremities by three planes, which are set on the alternate lateral planes.
34. Six-sided prism, acuminated on both extremities by three planes, which are set on the alternate lateral edges.
35. Double eight-sided pyramid, accuminated on both extremities by four planes, which are set on the alternate lateral edges.

MINIMUM, in the higher geometry, the least quantity attainable in a given case.

MINOR, in law, is an heir, either male or female, before they arrive at the age of twenty-one; during the minority of such, they are usually incapable of acting for themselves.

Minor, in logic, the second proposition of a regular syllogism.

Minor, in music, signifies less, and is applied to certain concords or intervals which differ from others of the same denomination by half a tone: thus we say a third minor, meaning a less third; a sixth major and minor.

MINT, the place in which the public money is coined. See Coining.

The officers of the mint are, 1. The warden of the mint, who is chief; he oversees the other officers, and receives the bullion. 2. The master worker; who receives the bullion from the warden, causes it to be melted, delivers it to the moneyers, and when it is coined receives it again. 3. The comptroller; who is the overseer of all the inferior officers, and sees that all the money is made to the just assize. 4. The assay-master; who weighs the gold and silver, and sees that it is according to the standard. 5. The auditor; who takes the accounts. 6. The surveyor of the melting; who, after the assay-master has made trial of the bullion, sees that it is cast out, and not altered after it is delivered to the melter. 7. The engraver; who engraves the stamps and dyes for the coinage of the money. 8. The clerk of the irons; who sees that the irons are clean and fit to work with. 9. The melter; who melts the bullion before it is coined. 10. The provost of the mint; who provides for, and oversees all the moneyers. 11. The blanchers; who anneal and clease the money. 12. The moneyers; some of whom forge the money, some shear it, some round and mill it, and some stamp or coin it. 13. The porters; who keep the gate of the mint.

Mint. See Mentha.

MINUASTIA, a genus of the triandria trigynia class and order. The cal. is 5-leaved; cor. none; caps. 1-celled, 3-valved. There are three species, herbs of Spain.

MINUTE, in geometry, the sixtieth part of a degree of a circle.

Minutes are denoted by one acute accent, thus ($'$); as the second, or sixtieth part of a minute, is by two such accents, thus ($''$); and the third by three ($'''$), &c.

Minute of time, the sixtieth part of an hour.

MIRABILIS, *marvel of Peru*; a genus of the monogynia order, in the pentandria class of plants, and in the natural method ranking with those of which the order is doubtful. The corolla is funnel shaped above; the calyx inferior; the nectarium globular, containing the germen. The most remarkable species are, 1. The jalapa, or common marvel of Peru. Of this there are varieties, with white flowers, with yellow flowers, with purple flowers, with red flowers, with white and yellow flowers, white and purple flowers, purple and yellow flowers, red and yellow flowers. 2. The longiflora, or long-flowered mirabilis, with all the branches and shoots terminated by white flowers in clusters, having very long tubes, nodding downward. 3. The dichotoma, dichotomous, or forked mirabilis, with smallish red flowers at the axillas, singly and close-sitting.

The roots of all these plants are purgative; but require to be given in a great quantity to operate equal to the true jalap, which is a species of convolvulus. See Convolvulus.

MIRROR, a speculum, looking-glass, or any polished body, whose use is to form the images of distinct objects by reflection of the rays of light.

Mirrors are either plane, convex, or concave. The first sort reflects the rays of light in a direction exactly similar to that in which they fall upon it, and therefore represents bodies of their natural magnitude. But the convex ones make the rays diverge much more than before reflexion, and therefore greatly diminish the images

of these objects which they exhibit; while the concave ones, by collecting the rays into a focus, not only magnify the objects they show, but will also burn very fiercely when exposed to the rays of the sun, and hence they are commonly known by the name of burning mirrors.

In ancient times the mirrors were made of some kind of metal; and from a passage in the Mosaic writings we learn, that the mirrors used by the Jewish women, were made of brass; a practice doubtless learned from the Egyptians.

Any kind of metal, when well polished, will reflect very powerfully; but of all others, silver reflects the most, though it has always been too expensive a material for common use. Gold is also very powerful; and all metals, or even wood, gilt and polished, will act very powerfully as burning mirrors. Even polished ivory, or straw nicely plaited together, will form mirrors capable of burning, if on a large scale.

Some of the more remarkable laws and phenomena of plane mirrors are as follow:

1. A spectator will see his image of the same size, and erect, but reversed as to right and left, and as far beyond the speculum as he is before it. As he moves to or from the speculum, his image will, at the same time, move towards or from the speculum also on the other side. In like manner if, while the spectator is at rest, an object be in motion, its image behind the speculum will be seen to move at the same rate. Also when the spectator moves, the images of objects that are at rest will appear to approach or recede from him, after the same manner as when he moves towards real objects.

2. If several mirrors, or several fragments or pieces of mirrors, be all disposed in the same plane, they will only exhibit an object once.

3. If two plane mirrors, or speculums, meet in any angle, the eye, placed within that angle, will see the image of an object placed within the same, as often repeated as there may be perpendiculars drawn determining the places of the images, and terminated without the angle. See OPTICS.

MISCHNA, or MISNA, the code or collection of the civil law of the Jews. The Jews pretend, that when God gave the written law to Moses, he gave him also another not written, which was preserved by tradition among the doctors of the synagogue, till rabbi Juda, surnamed the Holy, seeing the danger they were in, through their dispersion, or departing from the traditions of their fathers, judged it proper to reduce them to writing.

The misna is divided into six parts: the first relates to the distinction of seeds in a field, to trees, fruits, tythes, &c. The second regulates the manner of observing festivals: the third treats of women, and matrimonial cases: the fourth of losses in trade, &c. the fifth is on obligations, sacrifices, &c. and the sixth treats of the several sorts of purification. See TALMUD.

MISDEMEANOUR. A crime or misdemeanour is an act committed or omitted, in violation of a public law, either forbidding or commanding it.

MISLETOE. See VISCUM.

MISNOMER, the using of one name for another.

Where a person is described so that he may not be certainly distinguished and known from other persons, the omission, or in some cases the mistake of the name shall not avoid the grant. 11 Rep. 20.

If the christian name is wholly mistaken, this is regularly fatal to all legal instruments, as well declarations and pleadings as grants and obligations.

The mistake of the surname does not vitiate, because there is no repugnancy that a person shall have different surnames; and therefore, if a man enter into an obligation by a particular name, he may be impleaded by that name in the deed, and his real name brought in by an alias; and then the name in the deed he cannot deny, because he is estopped to say any thing contrary to his own deed. 2 Rol. Abr. 146.

MISPRISON, is generally understood to be of all such high offences as are under the degree of capital, but bordering thereon, and it is said that a misprison is contained in every treason and felony whatsoever; and, that if the king please, the offender may be proceeded against for the misprison only. 4 Black. 119.

MIS-RECITAL, in deeds, is sometimes injurious, and sometimes not; if a thing be referred to time, place, and number, and that is mistaken, all is void.

MITCHELLA, a genus of the tetrandria monogynia class and order. The cor. is 1-petalled; stigmas 4; berry trifid, 2-seeded. There is 1 species, an herb of N. America.

MITE, a small coin formerly current, equal to about one third part of a farthing.

It also denotes a small weight used by the moneyers. It is equal to the twentieth part of a grain, and is divided into twenty-four doits.

MITE. See ACARUS.

MITELLA, *bastard American sanicle;* a genus of the digynia order, in the decandria class of plants; and in the natural method ranking under the 13th order, succulentæ. The calyx is quinquefid; the corolla pentapetalous, and inserted into the calyx; the petals pinnatifid; the capsule unilocular and bivalved, with the valves equal. There are two species, both natives of North America, rising with annual herbaceous stalks from five or six to eight or nine inches in height, and producing spikes of small whitish flowers, whose petals are fringed on their edges.

MITHRIDATEA, a genus of the monandria monogynia class and order. The cal. is four-cleft; cor. none; fruit globular, depressed. There is one species, a tree of Madagascar.

MITTIMUS, a writ by which records are transferred from one court to another. This word is also used for the precept directed to a gaoler, under the hand and seal of a justice of the peace, for the receiving and safe keeping a felon, or other offender, by him committed to goal.

MIZEN, in the sea-language, is a particular mast or sail. The mizen-mast stands in the sternmost part of the ship. Its length is by some accounted the same with the height of the main-top-mast, from the quarter-deck: or half the length of the mainmast, and half as thick. The sail which belongs to the mizen-mast, is called the mizen-sail: and when the word mizen is used at sea, it always means the sail.

MNASIUM, a genus of the hexandria monogynia class and order. The cal. is 1-leaved, 3-parted; cor. 1-

petalled, 3-parted; antheræ 4-cornered; germ 3-lobed; stigmas 3. There is 1 species, an aquatic of Guiana.

MNIARUM, a genus of the monandria digynia class and order. The cal. is 4-parted, superior; cor. none; seed 1. There is one species, an herb of New Zealand.

MNIUM, *marsh-moss;* a genus of the natural order of musci, belonging to the cryptogamia class of plants. The anthera is operculated; the calyptra smooth; the female capitulum naked and powdery, remote. There are 24 British species, but none have any remarkable property except the following: 1. The fontanum is an elegant moss, frequent in bogs, and on the borders of cold springs. It is from two to four inches high: the stalks are simple at the base, and covered with a rusty down; but higher up are red, and divided into several round, single, taper branches, which proceed nearly from the same point. The leaves are not more than $\frac{1}{12}$th of an inch long, lanceolate and acute, of a whitish-green colour, and so thinly set, that the red stalk appears between them. This moss, as it may be seen at a considerable distance, is a good mark to lead to the discovery of clear and cold springs. Dr. Withering informs us, that wherever this moss grows, a spring of fresh water may be found without much digging. 2. The hygrometricum grows in woods, heaths, garden-walks, walls, old trees, decayed wood, and where coals or cinders have been laid. It is stemless, has tips inversely egg-shaped, nodding, and bright yellow. If the fruit-stalk is moistened at the base with a little water or steam, the head makes three or four revolutions; if the head is moistened, it turns back again.

MOAT, or Ditch, in fortification, a deep trench dug round the rampart of a fortified place, to prevent surprizes.

The brink of the moat, next the rampart, is called the scarpe; and the opposite one, the counterscarpe.

A dry moat round a large place, with a strong garrison, is preferable to one full of water, because the passage may be disputed inch by inch; and the besiegers, when lodged in it, are continually exposed to the bombs, grenades, and other fire-works, which are thrown incessantly from the rampart into their works. In the middle of dry moats there is sometimes another small one, called cunette; which is generally dug so deep, till they find water to fill it.

The deepest and broadest moats are accounted the best, but a deep one is preferable to a broad one: the ordinary breadth is about twenty fathoms, and the depth about sixteen.

To drain a moat that is full of water, they dig a trench deeper than the level of the water, to let it run off; and then throw hurdles upon the mud and slime, covering them with earth or bundles of rushes, to make a sure and firm passage.

MODE, in logic, called also syllogistic mood, a proper disposition of the several propositions of a syllogism, in respect of quantity and quality.

As in all the several dispositions of the middle term, the propositions of which a syllogism consists may be either universal or particular, affirmative or negative; the due determination of these, and putting them together as the laws of argumentation require, constitute what logicians call the moods of syllogisms. Of these moods there are a determinate number to every figure, including all the possible ways in which propositions, differing in quantity or quality, can be combined, according to any disposition of the middle term, in order to arrive at a just conclusion. There are two kinds of moods, the one direct, the other indirect.

The direct mood is that wherein the conclusion is drawn from the premises directly and immediately, as, "Every animal is a living thing, every man is a living animal; therefore every man is a living thing." There are fourteen of these direct moods, four whereof belong to the first figure, four to the second and six to the third. They are denoted by so many artificial words framed for that purpose, viz. 1. Barbara, celarant, darii, ferioque. 4. Baralip, celantes, dabitis, fapesmo, frisesom. 2. Cesare, camestres, festino, baroco. 3. Darapti, felapton, disamis, datisi, bocardo, ferison. The use and effect of which words lie wholly in the syllables, and the letters of which the syllables consist; each word, for instance, consists of three syllables, denoting the three propositions of a syllogism, viz. major, minor, and conclusion: add, that the letters of each syllable are either vowels or consonants; the vowels are A, which denotes an universal affirmative; E, an universal negative; I, a particular affirmative; and O, a particular negative: thus, Barbara is a syllogism or mood of the first figure, consisting of three universal affirmative propositions: Baralip, one of the fourth figure, consisting of two universal affirmative premises, and a particular affirmative conclusion. The consonants are chiefly of use in the reduction of syllogisms. The indirect mood, is that wherein the conclusion is not inferred immediately from the premises, but follows from them by means of a conversion; as, "Every animal is a living thing, every man is an animal; therefore some living thing is a man."

Mode, in music, a particular system, or constitution of sounds, by which the octave is divided into certain intervals, according to the genus. The doctrine of the ancients respecting modes is rendered somewhat obscure, by the difference among their authors as to the definitions, divisions, and names of their modes. Some place the specific variations of tones, or modes, in the manner of division, or order of the concinnous parts; and others merely in the different tension of the whole: *i. e.* as the whole series of notes are more acute or grave, or as they stand higher or lower in the great scale of sounds.

MODEL, in a general sense, an original pattern, proposed for any one to copy or imitate. This word is particularly used in building, for an artificial pattern made in wood, stone, plaster, or other matter, with all its parts and proportions, in order for the better conducting and executing some great work, and to give an idea of the effect it will have in large. In all great buildings, it is much the surest way to make a model in relievo, and not to trust to a bare design or draught. There are also models for the building of ships, &c. and for extraordinary staircases, &c.

They also use models in painting and sculpture; whence, in the academies, they give the term model to a naked man or woman, disposed in several postures, to afford an opportunity to the scholars to design him in various views and attitudes.

Models in imitation of any natural or artificial sub-

stance, are most usually made by means of moulds composed of plaster of Paris. For the purpose of making these moulds, this kind of plaster is much more fit than any other substance, on account of the power it has of absorbing water, and soon condensing into an hard substance, even after it has been rendered so thin as to be of the consistence of cream. This happens in a shorter or longer time, as the plaster is of a better or worse quality; and its good or bad properties depend very much upon its age, to which, therefore, particular regard ought to be had. It is sold in the shops at very different prices; the finest being made use of for casts, and the middling sort for moulds. It may be very easily coloured by means of almost any kind of powder excepting what contains an alkaline salt; for this would chemically decompose the substance of it, and render it unfit for use, the gypsum or plaster being a sulphat of lime, which would be decomposed by the alkali precipitating the lime. A very considerable quantity of chalk would also render it soft and useless, but lime hardens it to a great degree. The addition of common size will likewise render it much harder than if mere water is made use of. In making either moulds or models, however, we must be careful not to make a mixture too thick at first; for if this is done, and more water added to thin it, the composition must always prove brittle, and of a bad quality.

The particular manner of making models (or casts, as they are also called) depends on the form of the subject to be taken. The process is easy where the parts are elevated only in a slight degree, or where they form only a right or obtuse angle with the principal surface from which they project; but where the parts project in smaller angles, or form curves inclined towards the principal surface, the work is more difficult. This observation, however, holds good only with regard to hard and inflexible bodies; for such as are soft may often be freed from the mould, even though they have the shape last mentioned. But though this is the case with the soft original substance, it is not so with the inflexible model when once it is cast.

The moulds are to be made of various degrees of thickness, according to the size of the model to be cast; and may be from half an inch to an inch, or, if very large, an inch and an half. Where a number of models are to be taken from one mould, it will likewise be necessary to have it of a stronger contexture than where only a few are required, for very obvious reasons.

It is much more easy to make a mould for any soft substance than a rigid one, as in any of the viscera of the animal body: for the fluidity of the mixture makes it easily accommodate itself to the projecting parts of the substance; and as it is necessary to inflate these substances, they may be very readily extracted again, by letting out the air which distended them.

When a model is to be taken, the surface of the original is first to be greased, in order to prevent the plaster from sticking to it; but if the substance itself is slippery, as is the case with the internal parts of the human body, this need not be done: when necessary, it may be laid over with linseed oil by means of a painter's brush. The original is then to be laid on a smooth table, previously greased, or covered with a cloth, to prevent the plaster sticking to it; then surround the original with a frame or ridge of glazier's putty, at such a distance from it as will admit the plaster to rest upon the table on all sides of the subject for about an inch, or as much as is sufficient to give the proper degree of strength to the mould. A sufficient quantity of plaster is then to be poured as uniformly as possible over the whole substance, until it is every where covered to such a thickness as to give a proper substance to the mould, which may vary in proportion to the size. The whole must then be suffered to remain in this condition till the plaster has attained its hardness: when the frame is taken away, the mould may be inverted, and the subject removed from it; and when the plaster is thoroughly dry, let it be well seasoned.

Having formed and seasoned the moulds, they must next be prepared for the casts by greasing the inside of them with a mixture of olive oil and lard in equal parts, and then filled with fine fluid plaster, and the plane of the mould formed by its resting on the surface of the table, covered to a sufficient thickness with coarse plaster, to form a strong basis or support for the cast where this support is requisite, as is particularly the case where the thin and membranous parts of the body are to be represented. After the plaster is poured into the mould, it must be suffered to stand until it has acquired the greatest degree of hardness it will receive; after which the mould must be removed: but this is attended with some difficulty when the shape of the subject is unfavourable; and in some cases the mould must be separated by means of a small mallet and chisel. If by these instruments any parts of the model should be broken off, they may be cemented by making the two surfaces to be applied to each other quite wet; then interposing betwixt them a little liquid plaster: and lastly, the joint smoothed, after being thoroughly dry. Any small holes that may be made in the mould can be filled up with liquid plaster, after the sides of them have been thoroughly wetted, and smoothed over with the edge of a knife.

In many cases it is altogether impracticable to prepare a mould of one piece for a whole subject; and therefore it must be considered how this can be done in such a manner as to divide the mould into the fewest pieces. This may be effected by making every piece cover as much of the pattern as possible, without surrounding such projecting parts, or running into such hollows as would not admit a separation of the mould. Where any internal pieces are required, they are first to be made; and then the outer pieces, after the former have become hard.

Besides the models which are taken from inanimate bodies, it has been frequently attempted to take the exact resemblance of people while living, by using their face as the original of a model, whence to take a mould; and the operation, however disagreeable, has been submitted to by persons of the highest ranks in life. A considerable difficulty occurs in this, however, from the person's being apt to shrink and distort his features when the liquid is poured upon him; neither is he altogether without danger of suffocation, unless the operator well understands his business.

To avoid the former inconvenience, it will be proper to mix the plaster with warm instead of cold water, by which means the person will be under no temptation to shrink; and to prevent any danger of a fatal accident, the following method is to be practised: Having laid the person

horizontally on his back, the head must first be raised by means of a pillow to the exact position in which it is naturally carried when the body is erect; then the parts to be represented must be very thinly covered over with fine oil of almonds, by means of a painter's brush: the face is then to be first covered with fine fluid plaster, beginning at the upper part of the forehead, and spreading it over the eyes, which are to be kept close, that the plaster may not come in contact with the globe; yet not closed so strongly as to cause any unnatural wrinkles. Cover then the nose and ears, plugging first up the meatus auditorii with cotton, and the nostrils with a small quantity of tow rolled up, of a proper size to exclude the plaster. During the time that the nose is thus stopped, the person is to breathe through the mouth: in this state the fluid plaster is to be brought down low enough to cover the upper lip, observing to leave the rolls of tow projecting out of the plaster. When the operation is thus far carried on, the plaster must be suffered to harden; after which the tow may be withdrawn, and the nostrils left free and open for breathing. The mouth is then to be closed in its natural position, and the plaster brought down to the extremity of the chin. Begin then to cover that part of the breast which is to be represented, and spread the plaster to the outsides of the arms and upwards, in such a manner as to meet and join that which is previously laid on the face: when the whole of the mass has acquired its due hardness, it is to be cautiously lifted, without breaking or giving pain to the person. After the mould is constructed, it must be seasoned in the manner already directed; and when the mould is cast, it is to be separated from the model by means of a small mallet and chisel. The eyes, which are necessarily shown closed, are to be carved, so that the eye-lids may be represented in an elevated posture; the nostrils hollowed out, and the back part of the head, from which, on account of the hair, no mould can be taken, must be finished according to the skill of the artist. The edges of the model are then to be neatly smoothed off, and the bust fixed on its pedestal.

MODULATION, in music, the art of conducting harmony, in composition, or extemporary performance, through those keys and modes which have a due relation to the fundamental, or original key. Though every piece, as is well known, has its principal or governing key, yet, for the sake of contrast and relief, it is not only allowable but necessary to pass from key to key, and from mode to mode; to assume different sharps or flats, and lead the ear through those transitions of tone and harmony which interest the feelings and delight the ear. But though in grand compositions there is no quality of a greater importance than that of a masterly modulation, it is not easy to lay down rules for its accomplishment. Sometimes a gradual and almost insensible evolution of harmony is requisite to the composer's object; at other times, a bold and sudden change can alone produce the necessary effect.

MODULE. See ARCHITECTURE.

MODUS DECIMANDI, in law, is where money, land, or other valuable consideration, has been given, time out of mind, to the minister or parson of any certain place, in the room of tithes. A clergyman may sue in a spiritual court for a modus decimandi; yet if the modus is denied there, or a custom is to be tried, the trial thereof belongs to the courts of common law. When lands are converted to other uses, as in the case of hay-ground turned into tillage, the modes may be discharged, and the tithes paid again in kind.

MOERHINGIA, mossy chickweed, in botany, a genus of the octandria digynia class of plants, the flower of which is composed of four short, undivided petals; and its fruit is a subglobose capsule, with one cell, in which are contained numerous roundish seeds. There is one species.

MOLE. See ZALPA.

MOLLUGO, African chickweed; a genus of the trigynia order, in the triandria class of plants; and in the natural method ranking under the 22d order, caryophyllei. The calyx is pentaphyllous; there is no corolla; the capsule is trilocular, and trivalved. There are six species, annuals of the Cape, and of the E. and W. Indies.

MOLUCCELLA, in botany, a genus of the didynamia-gymnospermia class of plants, the flower of which is monopetalous and labiated; the upper lip being entire, and the lower one trifid: the seeds are turbinated, and contained in the bottom of the cup. One annual species.

MOLYBDATS. These salts, composed of molybdic acid combined with the alkalies and earths, were formed by Scheele; but their properties are still almost completely unknown. The supermolybdat of potass alone has been described with some detail. It is formed by detonating one part of sulphuret of molybdenum and three parts of nitre in a crucible. By dissolving the reddish mass which remains after this operation, and filtering, a solution of sulphat of potass and molybdat of potass is obtained. By evaporating the solution, the sulphat of potass is separated; when sulphuric acid is dropt into the remaining liquid, supermolybdat of potass is precipitated. This salt is soluble in water. Its solution chrystallizes by evaporation in small rhomboidal plates inserted into each other. They are bright, and have a metallic taste. When exposed to the blow-pipe upon charcoal, they melt without swelling, and are converted into small globules, which are quickly absorbed by the charcoal. When melted with a mixture of phosphat of soda and of ammonia (or microscomic salt), they communicate a green tinge. Hot water dissolves them completely, and prussiat of potass occasions in this solution a reddish brown precipitate. When a solution of muriat of tin is poured upon them, they acquire a blue colour.

MOLYBDENUM. The Greek word μολυβδαινα, and its Latin translation plumbago, seem to have been employed by the ancients to denote various oxides of lead; but by the moderns they were applied indiscriminately to all substances possessed of the following properties: light, friable, and soft, of a dark colour and greasy feel, and which leaves a stain upon the fingers. Scheele first examined these minerals with attention. He found that two very different substances had been confounded together. To one of these, which is composed of carbon and iron, he appropriated the word plumbago; the other he called molybdena.

Molybdena is composed of scaly particles adhering slightly to each other. Its colour is blueish, very much resembling that of lead. Scheele analysed it in 1778, and obtained sulphur and a whitish powder, which possesses the properties of an acid, and which, therefore, he

called acid of molybdena. Bergman suspected this acid, from its properties, to be a metallic oxide; and at his request, Hielm, in 1782, undertook the laborious course of experiments by which he succeeded in obtaining a metal from this acid. His method was to form it into a paste with linseed oil, and then to apply a very strong heat. This process he repeated several times successively. To the metal which he obtained he gave the name of molybdenum. The experiments of Scheele were afterwards repeated by Pelletier, Ilseman, and Heyer; and not only fully confirmed, but discovered many new facts, and the metallic nature of molybdic acid was put beyond a doubt: though, in consequence of the very violent heat necessary to fuse molybdenum, only very minute grains of it have been hitherto obtained in the state of a metal. Still more lately, Mr. Hatchett has published a very valuable set of experiments, which throw much new light upon the nature of this metal.

Molybdenum is externally of a whitish-yellow colour, but its fracture is a whitish-grey. Hitherto it has only been procured in small grains agglutinated together in brittle masses. Its specific gravity is 7.500. It is almost infusible in our fires.

When exposed to heat in an open vessel, it gradually combines with oxygen, and is converted into a white oxide, which is volatilized in small brilliant needle-form crystals. This oxide, having the properties of an acid, is known by the name of molybdic acid.

From the experiments of Mr. Hatchet, it follows that molybdenum is capable of combining with four different proportions of oxygen, and of forming four oxides; namely, 1. The black; 2. The blue; 3. The green, to which Mr. Hatchet has given the name of molybdous acid; and, 4. The yellow or white, or the molybdic acid.

1. The protoxide, or black oxide, may be obtained by mixing molybdic acid with charcoal powder in a crucible, and applying heat. A black mass remains, which is the black oxide. It seems to contain only a very minute quantity of oxygen.

2. The blue oxide may be obtained by the same process not carried so far: it is formed also whenever a plate of tin is plunged into a solution of molybdic acid.

3. The peroxide, or molybdic acid, is obtained by distilling six parts of diluted nitric acid repeatedly off native molybdena in powder. A white mass is left behind, composed of sulphuric and molybdic acids. A little pure water washes away the sulphuric acid, and molybdic acid remains behind. This acid has at first a white colour; but when melted and sublimed, it becomes yellow.

Molybdenum combines readily with sulphur; and the compound has exactly the properties of molybdena, the substance which Scheele decompounded. Molybdena is therefore sulphuret of molybdenum. The reason that Scheele obtained from it molybdic acid was, that the metal combined with oxygen during his process. Sulphuret of molybdenum may be formed also by distilling together one part of molybdic acid and five parts of sulphur. Molybdenum is also capable of combining with phosphorus.

Few of the alloys of this metal have been hitherto examined.

It seems capable of uniting with gold. The alloy is probably of a white colour. It combines readily with platinum in the state of an oxide. The compound is fusible. Its specific gravity is 20.000.

The alloys of molybdenum with silver, iron, and copper are metallic and friable; those with lead and tin are powders which cannot be fused. Several other combinations have been made both by Hielm and Richter; but as the metals which they tried were alloyed not with molybdenum, but with molybdic acid, they cannot be considered as by any means the same with the alloys formed by molybdenum itself.

Molybdenum, *Ores of.* These are very scarce, having been found only in Sweden, Germany, Corniola, among the Alps, near Inverness, and in the island of Lewis, in Scotland. The only species known is molybdena, which is found commonly massive: sometimes, however, it is chrystallized in hexædral tables. Colour light leady-grey; sometimes with a shade of red. Streak blueish grey, metallic. Powder bloeish texture, foliated lamellæ, slightly flexible. Specific gravity 4.5 to 4.73. Marks blueish-black. A piece of resin rubbed with this mineral becomes positively electric. Insoluble in sulphuric and muriatic acids. Composed of about

60	molybdenom
40	sulphur
100	

MOMENT, in the doctrine of infinites, denotes the same with infinitesimal.

Moment, momentom, in mechanics, signifies the same with impetus, or the quantity of motion in a moving body; which is always equal to the quantity of matter, multiplied into the velocity; or, which is the same thing, it may be considered as a rectangle under the quantity of matter and velocity.

MOMORDICA, male balsam apple; a genus of the syngenesia order, in the monœcia class of plants; and in the natural method ranking under the 34th order, cucurbitaceæ. The male calyz is quinquefid; the corolla sexpartite; the filaments are three in number. The female calyx is trifid; the corolla quinquepartite; the style trifid, the fruit is an apple parting asunder with a spring. There are eight species, the most remarkable of which are, 1. This is a native of Asia; and has a trailing stalk like those of the cucumber or melon, with smooth leaves, cut into several segments, and spread open like a hand. The fruit is oval, ending in acute points, having several deep angles, with sharp tubercles placed on their edges. It changes to a red or purlish colour when ripe, opening with elasticity, and throwing out its seeds. 2. The elaterium, wild or spurting cucumber, has a large fleshy root, somewhat like briony, whence come forth, every spring, several thick, rough, trailing stalks. The flowers come out from the wings of the stalks: these are male and female, growing at different places on the same plant like those of the common cucumber: but they are much less, of a pale yellow colour, with a greenish bottom; the male flowers stand upon thick, short, foot stalks, but the female flowers sit upon the young fruit; which, after the flower is faded, grows of an oval form, an inch and a half long, swelling like a cucumber, of a grey colour, like the leaves, and covered over with short prickles. This species has one of its names from the property of casting out its seeds, together with the violent juice, in

which the seeds are lodged, with a violent force, if touched while ripe.

The first species is famous in Syria for curing wounds. The natives cut open the unripe fruit, and infuse it in sweet oil, which they expose to the sun for some days, until it becomes red; and then present it for use. Dropped on cotton, and applied to a fresh wound, the Syrians reckon this oil the best vulnerary next to balsam of Mecca, having found by experience that it often cures large wounds in three days. The leaves and stems of this plant are used for arbours or bowers. The elaterium of the shops is the fruit, or rather the inspissated fæcula, of the juice of the unripe fruit of the wild cucumber. It is usually sent us from Spain and the southern parts of France, where the plant is common. We receive it in small, flat, whitish lumps, or cakes, that are dry, and break easily between the fingers. It is of an acrid, nauseous, bitter taste, and has a strong offensive smell when newly made; but these, as well as its other properties, it loses after being kept for some time. It is a very violent purge and vomit, and is now but seldom used.

MOMOTUS, a genus of birds of the order picæ. The generic character is, bill strong, slightly curved, serrate at the edges; nostrils feathered; tongue feathered; tail wedged; feet formed for walking. There is but one species, the Brasiliensis, that inhabits Brasil; size of a blackbird; eighteen inches long; lives solitarily in unfrequented forests; building a nest of dry gras on the ground, or in holes abandoned by the armadillo, and lays too eggs; feeds on insects and raw flesh, the fragments of which it macerates in water; when taken, it strikes violently with its bill. Its voice is harsh, weak, tremulous.

MONADELPHIA, (from μονος, *alone*, and αδελφια, *brotherhood*,) a "single brotherhood;" the name of the 16th class in Linnæus's sexual system, consisting of plants with hermaphrodite flowers; in which all the stamina, or male organs of generation, are united below into one body or cylinder, through which passes the pointal or female organ. See BOTANY.

MONANDRIA, (from μονος, *alone*, and ανηρ, a *man* or *husband*;) the name of the first class in Linnæus's sexual system; consisting of plants with hermaphrodite flowers, which have only one stamen or male organ.

MONARDA, Indian horehound; a genus of the monogynia order, in the diandria class of plants; and in the natural method ranking under the 42d order, verticillatæ. The corolla is unequal, with the upper lip linear, involving the filaments; there are four seeds. There are seven species; the most remarkable is the didyma, a native of North America. It is herbaceous. The flowers, which are of a bright red, surround the stalk in whorls, each whorl containing about 14 flowers; and are succeeded by four small kidney-shaped shining seeds, lodged in the bottom of the permanent flower-cup. The Indians superstitiously believe that a fumigation of this plant is affectual for driving away the devil.

MONAS, a genus of vermes, order infusoria. The generic character is worm invisible to the naked eye, most simple, pellucid, resembling a point. There are five species: the termo is a most minute, simple gelatenous point: to be found in most animal and vegetable infusions: of all animals the most minute, being so extremely delicate and transparent, as often to elude the most highly magnifying powers, blending in a manner with the water in which it swims.

MONETIA, a genus of the class and order tetrandria monogynia. The cal. is four-cleft; petals four; berry two-celled; seeds solitary. There is one species, a shrub of the E. Indies.

MONEY. The æra of the invention of money is not easy to be settled. There is no room to doubt, but that in the earliest ages the ordinary way of traffic among men was by trucking or exchanging one commodity for another; but in course of time it was found necessary, in the way of commutative justice, to have some common measure or standard, according to which all things should be estimated.

Money is usually divided into real and imaginary. Real money includes all coins, whether of gold, silver, copper, or the like; such as guineas, crowns, pistoles, pieces of eight, ducats, &c. for an account of which we refer the reader to the article COIN.

Imaginary money, or money of account, is that which never existed, or, at least, which does not exist in real specie; but is a denomination invented or retained to facilitate the stating of accounts, by keeping them still on a fixed footing, not to be changed like current coins, which the authority of the sovereign sometimes raises or lowers, according to the exigencies of the state, of which kinds are pounds, livers, marks, maravedies, &c. See POUND, &c.

No person is obliged to take in payment any money which is not lawful metal, that is, of silver and gold, except for sums under sixpence. 2 Inst. 577.

But it was decided in Hilary term, 1790, that bank notes were considered as money, and therefore a proper tender in payment.

English MONEY *of account*, is the pound, shillings, and pence; the pound contains twenty shillings, and the shilling twelve pence.

The old Scotch MONEY *of account* was the pound, shilling, and penny; the pound containing twenty shillings, being equivalent to one shilling and eightpence English; and the shilling containing twelve pennies, equal to a penny English. There is also among them an account of marks, the mark being equivalent to one shilling $1\frac{1}{3}$ penny English: of this last kind they had formerly a silver coin.

French MONEY *of account*, in France, sous, cents, &c.

Dutch MONEY *of account*, is kept at Amsterdam and Rotterdam, the two chief trading places, in guilders, stivers, and penins; so that though goods are sold for other species, such as livre de gros, &c. yet all are reduced to the above denominations for the entries into their books. The exchanges are made with us in so many shillings to a pound sterling, though in most other places in deniers de-gros.

Spanish MONEY *of account*, is at Cadiz kept in rials of plate and its fractions; at Castile, in maravedies; at Valencia, in livres or dollars, sueldos and dineros; of which last twelve make a sueldo, and twenty sueldos a livre or dollar. Seventeen quartos, at Cadiz and Castile, make two rials vellon, which is now an imaginary coin, though formerly it was the principal one of the kingdom. A maravedie is another imaginary specie, of which seventeen is reckoned to a rial vellon. The ducat is also a fictitious

coin of eleven rials of plate in purchases, sales, and other mercantile transactions, except in exchanges, when it is valued at eleven rials of plate and one maravedie, or 575 maravedies.

Portuguese MONEY *of account*, is kept in reas, or res, making a separation at every hundred, thousandth, &c. 800 reas go to a moidore.

German and Swiss MONEY *of account*. At Coningsberg, Elbing, and Dantzic, accounts are kept in rixdollars and gros, or in Polish guilders, gros, and deniers, or penins. They exchange on Amsterdam in Polish gros for a livre de gros of six guilders current money of Amsterdam, and on Hamburg for the rixdollar. At Lubec, accounts are kept in marks, schellings, and deniers or penins-lubs, in which their exchanges are made. At Breslaw, accounts are kept in rixdollars and silver gros and penins; in the first of which species exchanges are made on Amsterdam for a certain number of stivers, bank money, and on Hamburg for rixdollars of Breslaw against rixdollars of Hamburg bank. At Hamburg, accounts are kept in marks, schellings, and deniers-lubs bank money, by those who have cash in the bank; but by those who have not, their books are generally kept in rixdollars, schellings, and denier current money. At Bremen, accounts are kept in rixdollars and gros, and it exchanges on Amsterdam rixdollars of seventy-gros for rixdollars of fifty stivers banco. At Leipsic and Naumbourg, accounts are kept in rixdollars, crowns, gros, and penins. At Berlin, and in all this kingdom, accounts are kept in guilders, gros, and penins. At Zurich, accounts are kept in rixdollars, creutzers, and hellers; reckoning their rixdollars (worth about 4*s*. 6*d*. sterling) at 108 of their creutzers. At frankfort on the Maine, and Hanaw, accounts are kept in rixdollars and creutzers. At Vienna, accounts are kept in guilders, creutzers, and penins, reckoning eight penins to a creutzer, and sixty creutzers to a guilder. At Nuremberg and Augsbourg, accounts are kept in guilders, creutzers, and hellers; at Liege, in livres, sols, and deniers.

In the canton of St. Gall, in Switzerland, accounts are kept in guilders, creutzers, and penins; or under the same denomination with the coins of the empire. In the canton of Basil, accounts are variously kept, some in rixdollars, schellings, and deniers; some in livres, schellings, and deniers; some in rixdollars, creutzers, and penins; and some in guilders, creutzers, and penins.

Italian MONEY *of account*. In the cities of Genoa and Novi, accounts are kept in livres, soldi, and denari; or in dollars of 100 soldis. At Milan accounts are kept in livres, soldis, and denari, to be counted like pounds, shillings, and pence, viz. twelve denaris to a soldi, &c. At Rome accounts are kept in crowns, julios, and bajoches, or grains and quartrins; the crown is divided into ten julios, and the julio into ten bajoches. At Leghorn, accounts are generally kept in dollars, soldi, and denari. At Florence, they keep their books and accounts in crowns, soldi, and denari, picoli or current money. At Naples, accounts are kept in ducats, florins, and grains. The accounts in Sicily are kept the same as at Naples. At Lucca they keep their accounts in crowns, livres, soldi, and denari; the crown is worth 7 livres 10 soldi; the livre, 20 soldi; and the soldi, 12 denari. At Venice, accounts are kept in livres, soldi, and denari, picoli or current; but the bank-entries are in livres, soldi, and grosses: both the current and bank-ducats of Venice make 24 soldi, or six livres and 4 soldi. At Bologna, accounts are kept in livres, soldi, and denari; the livre being 20 soldi, and the soldi 12 denari. At Bergam, the money of account is the same as at Bologna, and its proportions the same. At Parma accounts are kept in crowns, soldi, and denari; the crown is 20 soldi, and the soldi 20 denari. At Modena and Mantua, accounts are kept in livres, soldi and denari. In Savoy and Piedmont, accounts are kept in livres or lires, soldi, and quartrins. At Placentia, accounts are kept in crowns, soldi, and denari of mark; of which 12 denari make a soldi, and 20 soldi the crown. In the island of Sardinia, accounts are kept as in most parts of Italy, in livres, soldi, and denari. In the island of Malta, the money of account is the same with that of Sicily. In the island of Candia, the account is the same as at Venice.

Russian, Swedish, Danish, and Polish MONEY *of account*. In the trading places of the Russian empire, accounts are kept in roubles, grives, and moscosques, or in roubles and coppecks; 10 coppecks (each of which is equal to 2 moscosques) make a grive, and 100 coppecks, or 10 grives, is a rouble. In the kingdom of Sweden, accounts are kept in dollars, marks, and oorts; the dollar being worth 4 marks, and the mark 8 oorts. In Denmark, accounts are kept in marks and schellings: the rixdollar is worth 6 marks; the mark, 16 schellings; and the schelling, 3 penins. Accounts are kept at Bergen, and in other places in Norway, in Danish rixdollars, marks, and schellings. In Poland, accounts are kept in guilders, gros, and deniers, of which 18 deniers make a gros, and 30 gros a guilder: they here keep accounts also in rixdollars and gros, reckoning 90 of the latter to one of the former. At Riga, accounts are kept in rixdollars and gros, the former of which species consists of 90 of the latter.

Turkish MONEY *of account*. The Turks, in Europe, Asia, and Africa, account by purses, either of silver or gold (the last being only used in the seraglio), with half purses of gold, called also rizes: the purse of silver is equal to 1500 French livres, or about 65*l*. sterling; and the half purse in proportion: the purse of gold is 15,000 sequins, equal to 30,000 French crowns, or about 3,750*l*. sterling: this is seldom used but for presents to favourites, so that a purse simply signifies a purse of silver, or 1,500 livres. The merchants also use Dutch dollars, called astani or abouquels, with medins and aspers: the dollar is equal to 35 medins, and the medin to 3 aspers; the asper to a halfpenny sterling money.

Asiatic MONIES *of account* are as follow. In Persia, they account by the taman (called also man and tumein) and dinar-bisti; the taman is composed of 50 abassis, or 100 mamodies, or 200 chapes, or 10,000 dinars; which, accounting the abassi on the foot of 18 French sols, or the dinar on that of a denier, amounts to 3*l*. 12*s*. 6*d*. sterling the taman. They also account by larins, especially at Ormus, and on the coast of the Persian gulph: the larin is equivalent to 11*d*. sterling; and on that footing is used also in Arabia, and through a great part of the East Indies. Chinese moneys of account are the pic, picol, and tael; which, though in effect weights, do likewise serve as money of account, obtaining in Tonquin as

well as China: the pic is divided into 100 catis, some say 125: the cati into 16 taels, each tael equal to one ounce two drachms: the picol contains $66\frac{2}{3}$ caties; the tael is equivalent to 6*s.* 8*d.* sterling.

Japanese moneys of account are the schurites, cockiens, ocbans or oubans, and taels: 200 schuites are equal to 500 Dutch pounds, the cockien equal to 10 low-country pounds, 1000 ocbans make 45,000 taels.

Mogul money of account: at Surat, Agra, and the rest of the estates of the great mogul, they use lacres, acrees, or leeths, implying one hundred thousand; thus a lacre of rupees is 100,000 rupees; the lacre being nearly on the footing of the tun of gold in Holland, and the million of France.

Monies of account of other islands and coasts of India. Throughout Malabar, and at Goa, they use tangas, vintins, and pardos-xeraphin: the tanga is of two kinds, viz. of good and bad alloy; hence their custom is to account by good or bad money; the tanga of good alloy is better by one-fifth than the bad, so that 4 tangas good being allowed the pardos-xeraphin, there will be required 5 of the bad; 4 vintins good make a tanga likewise good; 15 barucos, a vintin; a good baruco is equal to a Portuguese ree, a French denier, or one-thirteenth of a penny sterling. In the island of Java they use the sontasapacou, fardos, and catis; which last money, together with the leeth or lacre, is much used throughout all the East Indies: the sonta is 200 caxas, or little pieces of that country, hung on a string, and is equal to eleven-twelfths of a penny sterling: five sontas make the sapacou. The fardos equal to 2*s.* 8*d.* sterling; the cati contains 20 taels; the tael 6*s.* 8*d.* sterling. There are islands, cities, and states, of the East Indies, whose monies of account are not here expressed, partly because reducible to some of the above-mentioned, and partly because we find no certain consistent account of them.

African MONEY *of account.* From Cape Verd to the Cape of Good Hope, all exchanges and valuations of merchandize are made on the foot of the macoute and piece; which though no monies of account (for those barbarians have no real monies, and therefore need no imaginary ones to estimate them by) yet serve in lieu thereof. At Loango de Boirie, and other places on the coast of Angola, the estimations are made by macoutes; and at Malimbo and Cabindo, on the same coast, the negroes reckon by pieces: among the first the macoute is equal to 10 pieces; ten macoutes make 100, which likewise gives us a kind of imaginary money. to estimate any purchase, exchange, &c. they fix on the one side the number of macoutes required; *e. gr.* for a negro; so that there are several bargains made for one; suppose, for instance, the slave to be fixed at 3,500 pieces, this amounts to 350 macoutes; to make up this number of macoutes in merchandize, they fix the price of each in macoutes. Two Flemish knives, *ex. gr.* are accounted one macoute; a copper bason, 2 pound weight, three; a barrel of gunpowder. three, &c. For the piece, it serves in like manner to estimate the value of goods, duties, &c. on either side, thus the natives require 10 pieces for a slave; and the Europeans put, for instance, a fusee at 1 piece, a piece of salampours at 4 pieces, &c. The cities of Barbary and Egypt, whither the Europeans traffic, reckon much after the same manner as in the Levant and the dominions of the grand seignor; for the rest, through that vast extent of coast where we trade for negroes, gold-dust, elephant's teeth, wax, leather, &c. either the miserable inhabitants do not know what money of account is, or, if they have any, it is only what strangers, settled among them, have introduced.

MONKEY. See SIMIA.

MONOCHORD, a musical instrument composed of one string, used to try the variety and proportion of sounds.

It is formed of a rule, divided and sub-divided into several parts, on which there is a moveable string stretched upon two bridges at each extreme. In the middle between these is a moveable bridge, by means of which, in applying it to the different division of the line, the sounds are found to bear the same proportion to each other as the division of the line, cut by the bridge. There are also monochords with forty-eight fixed bridges. The following is the account of a monochord invented by earl Stanhope:

1. The wire is not made either of brass or of iron, but of steel, which is very far superior. For, steel wire does not keep continually lengthening, as brass and iron wires do when they are stretched considerably. 2. The wire in this monochord does not, as usual, pull downwards on the bridges, but the whole wire forms one straight and horizontal line, by which means the moveable bridge, which determines the exact length of the wire, can be moved without altering the tension of the wire. This is not the case when the wire pulls downwards on the bridges. 3. The ends of the wire are not twisted round the two stout steel pins which keep it stretched; but each end of the wire is soft-soldered in a long groove formed in a piece of steel which goes over its corresponding pin. This is a great improvement. 4. One of those two steel pins is strongly fastened on a brass slider, which is moved by means of a screw with very fine threads, which screw has a large micrometer head minutely divided on its edge, and a corresponding nonius; so that the tension of the wire may be adjusted with the greatest precision, in order to obtain its exact pitch. 5. A slider is fixed across the top of the moveable bridge, and is moved by means of another screw with very fine threads; so that the length of the wire may be regulated with the greatest nicety in all cases. 6. The above-mentioned slider, which is on the top of the moveable bridge, is adjusted to the steel rod or scale, not by sight, or by the coincidence of lines, but by means of mechanical contact against projecting pieces of steel firmly fixed on that steel scale, which method is incomparably more correct. 7. Each bridge carries a metallic finger, which keeps the wire close to the top of the bridge, whilst the wire is made to vibrate. 8. The vibrations of the wire are produced by touching it with a piece of cork, with the same elastic force, and on the very same spot each time, namely, at the distance of one inch from the immoveable bridge.

MONNIESIA, a genus of the class and order, diadelphia pentandria. The calyx is five-parted; corolla stringent; stamina 3, capsules 5, 1-seeded. There is one species, an American annual.

MONOCULUS. Monoculus, a genus of the order aptera: the generic character is, feet formed for swim-

ning; body covered by a crustaceous tegument; eyes, in most species, approximated, and imbedded in the shell.

Of the monoculi, by far the major part are very small water-insects, requiring the assistance of a microscope for the investigation of their particular organs: some however are so large as to require no very minute inspection; and one species in particular, (if, indeed, it can be allowed to stand with propriety in the genus) is of a size so gigantic, that it is generally considered as the largest of the crustaceous tribe. This animal is the monoculus polyphemus of Linnæus, commonly distinguished by the title molucca or king-crab. Specimens are sometimes seen of two feet in length, exclusive of the tail. It is a native of the Indian ocean, and is said to be generally found in pairs, or male and female swimming together. The colour of the whole animal is a yellowish-brown: the shell is very convex, rounded in front, and lunated behind, where it joins the lower part of the body: this, which is of the same crustaceous nature, is marked on each side into several spiny incisions; the legs, which are seven on each side, are situated beneath the concavity of the large or rounded part of the shell, and are each terminated by a double claw, those of the lowest pair having some additional processes: the branchiæ, or respiratory, organs are disposed in the form of several flat, rounded, imbricated lamellæ on each side the lower part of the body: the tail, which is strait, triangular, and of the same crustaceous nature with the rest of the shell, is equal in length to the whole body, and gradually tapers to a sharp point. The eyes in this species, instead of being approximated, as required in the Linnæan generic character, are extremely distant from each other, being situated towards the sides of the shell: they are of a semi-lunar form, and the surface is divided into a great number of minute conical convexities: this part however should be considered as only constituting the cornea or exterior covering of each eye; the organs themselves being, according to the observations of Mr. Petiver, in the Philosophical Transactions, placed on a pedicle beneath each of the above-mentioned semi-lunar corneæ. Petiver's words are these. "The whole structure of this animal is very remarkable, and particularly his eyes, viz. between the fourth and last pair of claws on each side, reckoning from his mouth, and excluding the small pair there placed, are inserted the rudiments of another pair, or a claw broken off on each side at the second joint or elbow; on these extremities are the eyes, like those of the horns of snails, but under the covert of a thick and opaque shell. Nature in that place has wonderfully contrived a transparent lantern, through which the light is conveyed, whose superficies very exactly resembles the great eyes of our large libellæ or adderbolts, which to the naked eye are plainly perceived to be composed of innumerable globuli: these, like them, are oblong, and guarded by a testaceous supercilium."

Of the European monoculi, by far the largest is the monoculus apus, which, when full-grown, measures nearly an inch and three quarters from the front to the end of the body, exclusive of the forked divisions of the tail. It is found in muddy stagnant waters, but is a rare species in this country, having been only observed in a few particular situations. In its general shape, it is considerably allied to the large exotic species before described, but the body is of a more lengthened form in proportion, with the hinder part naked, and divided into numerous joints: the branchiæ, or respiratory organs, are large, and are distributed into numerous imbricated rows on the under part of the body: beneath the front is a pair of jointed, trifid arms, extending on each side to a considerable distance; the eyes are placed near each other in front of the shell: the tail is terminated by a pair of long forks or cetaceous processes. The colour of the whole insect is a pale greenish-brown above, and reddish beneath. We are informed in vol. 40 of the Philosophical Transactions that this insect has been found in great plenty in a pond on Bexley's common, in Kent. It is also added that the same pond, having been perfectly dried, and being suddenly filled during a heavy thunder-storm, swarms of the same animal were again observed in it within the space of two days after.

Monoculus pulex, called, from its peculiar starting or springing motion, the water-flea, is an almost universal inhabitant of stagnant waters, appearing sometimes in such vast swarms as to cause an apparent discoloration of the water itself. It is an insect of a highly singular and elegant appearance, exhibiting, when magnified, a beautiful distribution of internal organs. Its general length is about the tenth of an inch, but it is sometimes seen considerably larger: its shape is oval, somewhat truncated in front, and sharply pointed behind: the body is inclosed in a bivalve, transparent shell, which, when examined by the microscope, appears finely reticulated: on each side the head is a strong transparent jointed arm, forking into two divisions, and terminating in several cetaceous branches: the tail, which is generally inclosed within the shell, is occasionally protruded in the form of a strong curved and pointed process: the eyes of this animal are of a singular construction; they are large in proportion to the insect, placed very near each other, appear to consist of many separate globules, of a black colour united under a common skin.

MONODON MONOCEROS, UNICORN NARWHAL, is a native of the northern seas, where it is sometimes seen of the length of more than twenty feet from the mouth to the tail; and is at once distinguishable from every other kind of whale by its very long, ivory-like tooth, which is perfectly straight, of a white or yellowish-white colour, spirally wreathed throughout its whole length, and gradually tapering to a sharp point. It measures from six to nine or ten feet in length, and proceeds from a socket on the one side of the upper jaw, having a large cavity at its base or root, running through the greater part of the whole length. In the young animals and occasionally even in the full grown ones, more especially in the males, there are two of these teeth, sometimes nearly of equal length, and sometimes very unequal in this respect: they are seated very close to each other at the base, and as their direction is nearly in a straight line, they diverge but little in their progress towards the extremities. The head of the narwhal is short, and convex above; the mouth small; the spiracle or breathing hole duplicated within; the tongue long; the pectoral fins small; the back, finless, widish, convex, becoming gradually accuminated towards the tail, which, as in other whales, is horizontal. The general form of the animal is rather long than thick;

in proportion to its size. The colour, when young, is said to be nearly black, but lighter on the belly: but as the animal advances in age, it becomes marbled or variegated with black and white on the back and sides, while the belly is nearly white. The skin is smooth, and there is a considerable depth of oil or blubber beneath it.

The narwhal chiefly inhabits the northern parts of Davis's Streights. Its food is said to consist of the smaller kind of flat-fish, as well as of actiniæ, medusæ, and many other marine animals. It is principally seen in the small open or unfrozen spots towards the coasts of the northern seas. To such places it resorts in multitudes, for the convenience of breathing, while at the same time it is sure of finding near the shores a due supply of food, and is very rarely seen in the open sea. It is taken by means of harpoons, and its flesh is eaten by the Greenlanders, both raw, boiled, and dried: the intestines and oil are also used as a food; the tendons make a good thread, and the teeth serve the purpose of hunting-horns as well as the more important ones of building tents and houses: but before this animal became distinctly known to the naturalists of Europe, they were held in high estimation, as the supposed horns of unicorns. Various medical virtues were also attributed to them, and they were even numbered among the articles of magnificence. A throne made for the Danish monarchs is said to be still preserved in the castle of Rosenberg, composed entirely of narwhals' teeth; the material being anticntly considered as more valuable than gold.

A specimen of this whale, measuring about eighteen feet, exclusive of the horn or tooth, was some time ago stranded on the coast of Lincolnshire, at no great distance from Boston, and was said to have been taken alive.

2. Monodon spurius, spurious narwhal. A species most allied to the narwhal, but not perhaps, strictly speaking, of the same genus: no teeth in the mouth, but from the extremity of the upper mandible project two minute, conic, obtuse teeth, alike curved at the tips, weak, and not above an inch long: body elongated, cylindric, black. Besides the pectoral fins, and horizontal tail, is also a minute dorsal fin. It must be numbered among the rarest of the whales. Its flesh and oil are considered as very purgative: inhabits the main ocean, seldom coming towards shore: feeds on the loligo: has a spiracle like other whales. Both flesh and oil are eaten, but not without apprehension, for the reason already mentioned.

Monodon narwhal, a genus of mammalia of the order cete, the generic character is, teeth two in the upper jaw, extending straight forward, long, spiral: spiracle on the fore and upper part of the head. It inhabits the Atlantic, swims rapidly, and is from 18 to 40 feet long and 12 broad. Skin white, spotted on the back with black: dorsal fins: pectoral, two small: head small: eyes very minute: what are commonly exhibited as the unicorns horns. See Plate XCI. Nat. Hist. fig. 269.

MONOECIA, from μονος, alone, and οικια, a house; the name of the 21st class of Linnæus's sexual method. See Botany.

MONOGYNIA, from μονος, alone, and γυνη, a woman; the name of the first order or subdivision in the first 13 classes of Linnæus's sexual method; consisting of plants, which, besides their agreement in their classic character, generally derived from the number of their stamina, have only one style, or female organ. See Botany.

MONOGRAM, a character or cypher, composed of one, two, or more letters interwoven; being a kind of abbreviation of a name, anciently used as a seal, badge, arms, &c.

MONOPOLY, is an allowance by the king, by his grant, commission, or otherwise, to any person or persons, bodies politic or corporate; or of, or for, the sole buying, selling, making, working, or using of any thing, whereby any person or persons, bodies politic or corporate, are sought to be restrained of any freedom or liberty they had before, or hindered in their lawful trade. 3 Inst. 181.

But it seems that the king's charter, impowering particular persons to trade to and from such place is void, so far as it gives such persons an exclusive right of trading and debarring all others; and it seems now agreed, that nothing can exclude a subject from trade but an act of parliament. Raym. 489.

MONOPTERUS. Monoptere, a genus of the fishes of the order apodal; the generic character is, body anguilliform; nostrils placed between the eyes; fin caudel.

1. The monopterous Javanicus, the only animal of this genus hitherto discovered, is thus described by the count de la Cepede, from the manuscripts of Commerson, by whom it was considered as a species of Muræna. The body is serpentiform, viscous, and destitute of conspicuous scales: the head thick, compressed, enlarging towards the back part, and terminated in front by a rounded muzzle: the gape is rather wide; the upper jaw scarcely projecting beyond the lower; both being furnished with close teeth: the gill membrane has only three rays, and the branchiæ are only three in number on each side; the lateral line, which is nearer the back than the belly, extends from the gills to the extremity of the tail, and is almost of a gold-colour: the back is of a livid brown or blackish colour. This fish is a native of the Indian seas and is very common about the coasts of Java, where it is considered as an excellent food.

MONSONIA, a genus of the dodecandria order, in the polyadelphia class of plants. The calyx is pentrophyllous; the corolla pentapetalous and irregular; the stamina are 15 in number, and coalited into five filaments; the style bifid; the capsule pentacoccous. There are three species.

MONSOON. See Wind.

MONTH, the twelfth part of a year. See Chronology.

MONTIA, water chickweed, a genus of the trigynia order, in the triandria class of plants; and in the natural method ranking with those of which the order is doubtful. The calyx is dyphyllous; the corolla monopetalous and irregular; the capsule unilocular, and trivalved. There is one species.

Mood, or *Mode*, in grammar, the different manner of conjugating verbs, serving to denote the different affections of the mind.

MOON. See Astronomy.

MOONSTONE. This is the purest felspar hitherto found. It occurs in Ceylon and Switzerland; and was first mentioned by Mr. Pini. Specific gravity, 2.559.

Colour white; sometimes with a shade of yellow, green, or red. Its surface is sometimes irridescent. A specimen of it analysed by Vauquelin, yielded

64	silica
20	alumina
14	potass
2	lime
100	

The whitish felspar, called petunze, yielded to the same chemist

74.0	silica
14.5	alumina
5.5	lime
94.0	

MOORING, in the sea-language, is the laying out the anchors of a ship in a place where she can ride secure. Mooring across, is laying out on each side; and mooring along, is to have an anchor in a river and a hawser on shore. When ships are laid up in ordinary, or are under orders of fitting for sea, the moorings are laid out in harbours, and consist of claws, pendant chains, cables, bridles, anchors, swivels, jews-harps, buoys, and chains.

MORDELLA, a genus of insects of the order coleoptera. The antennæ are thread-shaped and serrated; the head is deflected under the neck: the pappi are elevated, compressed, and obliquely blunted; and the elytra are bent backwards near the apex. There are six species.

MORÆA, a genus of the monogynia order, in the triandria class of plants; and in the natural method ranking under the 6th order, ensatæ. The corolla is hexapetalous: the three interior petals, patent; the rest like those of the iris. There are 17 species, beautiful exotics, resembling the iris.

MORINA, a genus of the monogynia order, in the triandria class of plants; and in the natural method ranking under the 48th order, aggregatæ. The corolla is unequal; the calyx of the fruit is monophyllous and dented; the calyx of the flower bifid; there is one seed under the calyx of the flower. There is one species.

MORINDA, a genus of the monogynia order, in the pentandria class of plants; and in the natural method ranking under the 48th order, aggregatæ. The flowers are aggregate and monopetalous; the stigmata bifid; the fruit plums aggregate or in clusters. There are 3 species, trees of the East Indies.

MORISONIA, a genus of the polyandria order, in the monadelphia class of plants; and in the natural method ranking under the 25th order, putamineæ. The calyx is single and bifid; the corolla tetrapetalous; there is one pistil; the berry has a hard bark, is unilocular, polyspermous, and pedecellated. There is one species, a tree of South America.

MORMYRUS, a genus of fishes of the branchiostegeous order, the generic character is, head smooth; teeth numerous, notched; aperture of the gills linear, without a cover; gill membrane with one ray; body scaly. There are three species. The kannume has the tail bifid, obtuse; dorsal fin with 63 rays. It inhabits the Nile; body whitish and much compressed.

MOROCCO, *maroquin*, in commerce, a fine kind of leather prepared of the skin of an animal of the goat-kind, and imported from the Levant, Barbary, &c.

The name was probably taken from the kingdom of Morocco, whence the manner of preparing it was borrowed, which is this: the skins being first dried in the hair, are steeped in water three days and nights; then stretched on a tanner's horse, beaten with a large knife, and steeped afresh in water every day: they are then thrown into a large vat in the ground, full of water, where quicklime has been slacked, and there lie fifteen days; whence they are taken, and again returned every night and morning. They are next thrown into a fresh vat of lime and water, and shifted night and morning for fifteen days longer: then rinsed in clear water, and the hair taken off on the leg with a knife, returned into a third vat, and shifted as before for eighteen days; steeped twelve hours in a river, taken out, rinsed, put in pails, where they are pounded with wooden pestles, changing the water twice; then laid on the horse, and the flesh taken off; returned into pails of new water, taken out, and the hair-side scraped; returned into fresh pails, taken out, and thrown into a pail of a particular form, having holes at bottom: here they are beaten for the space of an hour, and fresh water poured on from time to time; then being stretched on the leg, and scraped on either side, they are returned into pails of fresh water, taken out, stretched and sewed up all around in the manner of bags, leaving out the hinder legs as an aperture for the conveyance of a certain mixure.

The skins thus sewed are put in lukewarm water, where dogs excrements have been dissolved. Here they are stirred with long poles for half an hour, left at rest a dozen, taken out, rinsed in fresh water, and filled by a tunnel, with a preparation of water and sumac, mixed and heated over the fire till ready to boil; and, as they are filled, the hind legs are sewed up to stop the passage. In this state they are let down into the vessel of water and sumac, and kept stirring for four hours successively; taken out and heaped on one another; after a little time their sides are changed, and thus they continue an hour and a half till drained. This done, they are loosened, and filled a second time with the same preparation, sewed up again, and kept stirring two hours, piled up and drained as before. This process is again repeated, with this difference, that they are then only stirred a quarter of an hour; after which they are left till next morning, when they are taken out, drained on a rack, unsieved, the sumac taken out, folded in two from head to tail, the hair side outwards, laid over each other on the leg, to perfect their draining, stretched out and dried; then trampled under foot by two and two, stretched on a wooden table, what flesh and sumac remains scraped off, the hair-side rubbed over with oil, and that again with water.

They are then wrung with the hands, stretched, and pressed tight on the table with an iron-instrument like that of a currier, the flesh side uppermost; then turned, and the hair-side rubbed strongly over with a handful of rushes, to squeeze out as much of the oil remaining as possible. The first course of black is now laid on the hair-side, by means of a lock of hair twisted and steeped in a kind of black dye, prepared of sour beer, wherein pieces of old rusty iron have been thrown. When half-dried in the

air, they are stretched on a table, rubbed over every way with a paumelle, or wooden-toothed instrument, to raise the grain, over which is passed a light couch of water, then sleeked by rubbing them with rushes prepared for the purpose. Thus sleeked, they have a second course of black, then dried, laid on the table, rubbed over with a paumelle of cork, to raise the grain again; and, after a light couch of water, sleeked over anew; and to raise the grain a third time, a paumelle of wood is used.

After the hair-side has received all its preparations, the flesh-side is pared with a sharp knife for the purpose: the hair-side is strongly rubbed with a woollen cap, having before given it a gloss with barberries, citron, or orange. The whole is finished by raising the grain lightly, for the last time, with the paumelle of cork; so that they are now fit for the market.

Manner of preparing red Morocco: after steeping, stretching, scraping, beating, and rinsing the skins, as before, they are at length wrung, stretched on the leg, and passed after each other into water where alum has been dissolved. Thus alumed, they are left to drain till morning, then wrung out, pulled on the leg, and folded from head to tail, the flesh inwards.

In this state they receive their first dye, by passing them after one another into a red liquor prepared with laque, and some other ingredients, which the marowquineers keep a secret. This they repeat again and again, till the skins have got their first colour; then they are rinsed in clear water, stretched on the leg, and left to drain twelve hours; thrown into water through a sieve, and stirred incessantly for a day with long poles; taken out, hung on a bar across the water all night, white against red, and red against white, and in the morning the water stirred up, and the skins returned into it for twenty-four hours.

MORTALITY, *Bills of*, accounts of the numbers of deaths or burials in any parish or district. The establishment of registers of this kind in Great Britain, was occasioned by the plague, and an abstract of them was published weekly, to show the increase or decrease of the disorder, that individuals might judge of the necessity of removal, or of taking other precautions against it, and government be informed of the propriety or success of any public measures relating to the disorder. The first directions for keeping registers of births and burials were contained in the injunctions to the clergy, issued in the year 1538, which not being properly attended to, were enforced in 1547, and again in the beginning of the reign of Elizabeth, who also appointed a protestation to be made by the clergy, in which among other things, they promise to keep the register-book in a proper manner. One of the canons of the church prescribes very minutely in what manner entries are to be made in the parish-registers, and orders an attested copy of the register of each successive year to be annually transmitted to the bishop of the diocese or his chancellor, and to be preserved in the bishop's registry. These registers have only been occasionally communicated to the public, and that without sufficient particulars to supply much information; but in London, and the surrounding parishes, the parish-clerks are required to make a weekly return of burials, with the age and disease of which the person died; a summary of which account is published weekly; and on the Thursday before Christmas-day, a general account is made up for the whole year. These accounts of christenings and burials, taken by the company of parish clerks of London, were began 21st Dec. 1592, but were not made public till 1594; and towards the end of the following year, upon the ceasing of the plague, they were discontinued; at this time the London bills of mortality comprehended but 109 parishes. In 1603, the weekly bills of mortality were resumed, and have been regularly continued ever since; the number of parishes included in them has been increased at different times, and at present is 146.

Bills of mortality, especially such as give the ages of the dead and the disorders of which they died, furnish much useful information; they show the different degrees of healthiness of seasons or districts, the progress of population, and the probabilities of the duration of human life in any part of the usual term of existence; they are the foundations on which all tables of the value of annuities on lives, or depending on survivorship, have been constructed.

In 1662, Mr. John Graunt published some ingenious observations on the London Bills of Mortality, which were much enlarged in subsequent editions. Sir William Petty, in 1683, made considerable use of the information afforded by them, in his Political Arithmetic. In 1742, Mr. T. Simpson published his Treatise on Annuities, in which he inserted a table formed by Mr. Smart from the London bills of mortality, with some corrections which appeared necessary: in 1746, Mr. De Parcieux, in an Essai sur les Probabilites, de la Vie humaine, made some objections to Mr. Simpson's alterations in the London bills, but without sufficient foundation; and in 1752, Mr. Simpson, in a supplement to his Treatise on Annuities, made use of the same table from the London bills, but adapted to a different radix. In 1769, Dr. Price published his treatise on Reversionary Payments, in which, particularly in the subsequent editions, many valuable observations are to be found on the bills of mortality of different places, and very accurate tables are given of the expectation of life, and the value of annuities, according to these bills.

Dr. Price remarks, that in every place which just supports itself in the number of its inhabitants, without any recruits from other places; or where, for a course of years, there has been no increase or decrease, the number of persons dying every year at any particular age, and above it, must be equal to the number of the living at that age. The number, for example, dying every year, at all ages, from the beginning to the utmost extremity of life, must, in such situation, be just equal to the whole number born every year. And for the same reason, the number dying every year at one year of age and upwards, at two years of age and upwards, at three and upwards, and so on, must be equal to the numbers that attain to those ages every year; or, which is the same, to the numbers of the living at those ages. It is obvious, that unless this happens, the number of inhabitants cannot remain the same; it follows, therefore, that in a town or country, where there is no increase or decrease, bills of mortality which give the ages at which all die, will show the exact number of inhabitants; and also the exact law, according to which human life wastes in that town

or country. In order to find the number of inhabitants, the mean numbers dying annually at every particular age and upwards, must be taken as given by the bills, and placed under one another in the order of the second column: see Table 1, article EXPECTATION. These numbers will be the numbers of the living at 1, 2, 3, &c. years of age; and, consequently, the sum, diminished by half the number born annually, will be the whole number of inhabitants.

The bills of mortality, in some parts of Great Britain, are known to be materially defective; the deficiencies may chiefly be ascribed to the following circumstances: 1. Many congregations of dissenters, inhabiting towns, have their own peculiar burying-grounds; as have the Jews, and the Roman Catholics, who reside in London. 2. Some persons, from motives of poverty or convenience, inter their dead without any religious ceremony; this is known to happen in the metropolis, in Bristol, and Newcastle-upon-Tyne, and may happen in a few other large towns. 3. Children who die before baptism are interred without any religious ceremony, and consequently are not registered. 4. Negligence may be supposed to cause some omissions in the registers, especially in those small benefices, where the officiating minister is not resident. 5. Many persons employed in the army and in navigation die abroad, and consequently their burials remain unregistered. Whatever may be the total number of deaths and burials, which from these several circumstances are not brought to account, it has been computed that about 5000 of them may be attributed to the metropolis, and a large portion of the rest may be ascribed to the other great towns, and to Wales, where the registers are less carefully kept than in England.

The annual amount of the burials, as collected conformably to the population act, authorizes a satisfactory inference of diminishing mortality in England since the year 1780; the number of marriages and baptisms, indicates that the existing population in 1801, was to that of 1780, as 117 to 100, while the amount of registered burials remained stationary during the same period; the first five years of which, as well as the last five years, and all the 21 years taken together, equally averaged about 186,000 per annum.

The whole number of baptisms, collected for the purposes of the population act, was 6,436,110; of these 3,285,188 were males, and 3,150,922 females; so that the baptisms of males were 10,426 to 10,000 baptism of females. The whole number of the burials appeared to be 5,165,844; of which 2,575,762 were males, and 2,590,082 females, so that the burials of males were 9,944 to 10,000 burials of females. It may be inferred hence, that of 10,426 males born in England, only 9,944 die at home; therefore, about one in twenty-two dies abroad in the employments of war and commerce; a proportion which stongly marks the enterprising character of the nation.

MORTAR-PIECE, a short piece of ordnance, considerably thick and wide; serving to throw bombs, carcases, fire-pots, &c. See GUNNERY.

MORTGAGE, signifies a pawn of land or tenement, or any thing immoveable, laid or bound for money borrowed, to be the creditor's for ever, if the money is not paid at the day agreed upon; and the creditor holding land and tenement upon this bargain, is called tenant in the mortgage. He who pledges the pawn, or gage, is called the mortgager, and he who takes it, the mortgagee.

The last and best improvement of mortgages seems to be, that in the mortgage-deed of a term for years, or in the assignment thereof, the mortgagor should covenant for himself and his heirs, that if default is made in the payment of the money at the day, then he and his heirs will, at the costs of the mortgagee and his heirs, convey the freehold and inheritance of the mortgaged lands to the mortgagee and his heirs, or to such person or persons (to prevent merger of the term) as he or they shall direct and appoint: for the reversion, after the term of fifty or a hundred years, being little worth, and yet the mortgagee for want thereof continuing but a termer, and subject to a forfeiture, &c. and not capable of the privileges of a freholder; therefore when the mortgagor cannot redeem the land, it is but reasonable the mortgagee should have the whole interest and inheritance of it to dispose of it as absolute owner. 3 Bac. Abr. 633.

Although after breach of the condition, an absolute fee-simple is vested at common law in the mortgagee; yet a right of redemption being still inherent in the land, till the equity of redemption is foreclosed, the same right shall descend to, and is invested in, such persons as had a right to the land, in case there had been no mortgagee or incumbrance whatsoever; and as an equitable performance as effectually defeats the interests of the mortgage, as the legal performance does at common law, the condition still hanging over the estate till the equity is totally foreclosed; on this foundation it has been held that a person who comes in under a voluntary conveyance, may redeem a mortgage; and though such right of redemption is inherent in the land, yet the party claiming the benefit of it, must not only set forth such right, but also show that he is the person entitled to it. Hard. 465.

But if a mortgage is forfeited, and thereby the estate absolutely vested in the mortgagee at common law, yet a court of equity will consider the real value of the tenements, compared with the sum borrowed. And if the estate is of greater value than the sum lent thereon, they will allow the mortgagor, at any reasonable time, to recal or redeem the estate, paying to the mortgagee his principal, interest, and costs. This reasonable advantage, allowed to the mortgagors, is called the equity of redemption. 2 Black. 159.

It is a rule established in equity, analogous to the statute of limitation, that after twenty years possession of the mortgagee, he shall not be disturbed, unless there are extraordinary circumstances; as in the case of femes covert, infants, and the like. 3 Atk. 313.

MORTISE, or *Mortoise*, in carpentry, &c. a kind of joint, wherein a hole of a certain depth is made in a piece of timber, which is to receive another piece called a tenon.

MORTMAIN, signifies an alienation of lands and tenements, to any guild, corporation, or fraternity, and their successors, as bishops, parsons, vicars, &c. which may not be done without the king's licence, and the lord of the manor; or of the king alone, if it is immediately holden of him.

But in order to prevent any imposition in respect to the disposal of lands to charitable uses, which might arise in a testator's last hours, and in some measure, from po-

litical principles, to restrain devises in mortmain, or the too great accumulation of land in hands where it lies dead, and not subject to change possession, it is provided by stat. 9 G. II. c. 36, (called the statute of mortmain), that no manors, lands, tenements, rents, advowsons, or other hereditements, corporeal or incorporeal, whatsoever, nor any sum or sums of money, goods, chattels, stocks in the public funds, securities for money, or other personal estate whatsoever, to be laid out or disposed of in the purchase of any lands, tenements, or hereditaments, shall be given, limited, or appointed by will, to any person or persons, bodies politic or corporate, or otherwise for any estate or interest whatsoever; or any ways charged or incumbered by any person or persons whatsoever, in trust, or for the benefit of any charitable use whatsoever; but such gift shall be by deed indented, sealed and delivered in the presence of two or more credible witnesses, twelve calender months at least before the death of such donor, and be enrolled in the high court of chancery within six calender months after execution for the charitable use intended; and be without any power of revocation, reservation, or trust, for benefit of the donor. And all gifts and appointments whatsoever, of any lands, tenements, or other hereditaments, or of any estate or interest therein, or of any charge or incumbrance affecting or to affect any lands, tenements, or hereditaments, or any personal estate to be laid out in the purchase of any lands, tenements, or hereditaments, or any estate or interest therein, or of any charge or incumbrance affecting or to affect the same, to or in trust for any charitable use whatsoever, made in any other manner than is directed by this act, shall be absolutely null and void. But the two universities, their colleges, and the scholars upon the foundation of the colleges at Eton, Westminster, and Winchester, are excepted out of this act; but with this proviso, that no college shall be at liberty to purchase more advowsons than are equal in number to one moiety of the fellows or students upon the respective foundations.

MORUS, the MULBERRY-TREE, a genus of the tetrandria order, in the monœcia class of plants; and in the natural method ranking under the 53d order, scabridæ. The male calyx is quadripartite; and there is no corolla: the female calyx is tetraphyllous; there is no corolla; two styles; the calyx like a berry, with one seed. There are seven species, viz. 1. The nigra, or common black-fruited mulberry-tree, rises with an upright, large, rough trunk, dividing into a branchy and very spreading head, rising 20 feet high, or more. 2. The alba, or white mulberry-tree, rises with an upright trunk, branching 20 or 30 feet high. There is a variety with purplish fruit. 3. The papyrifera, or paper mulberry-tree of Japan, grows 20 or 30 feet high; having large palmated leaves, some trilobate, others quinquelobed; and monœcious flowers, succeeded by small black fruit. 4. The rubra, or red Virginia mulberry-tree, grows 30 feet high; and has large reddish berries. 5. The tinctoria, dyer's mulberry, or fustic, has oblong leaves more extended on one side at the base, with axillary thorns. It is a native of Brasil and Jamaica. 6. The tartarica, or Tartarian mulberry, has ovate oblong leaves, equal on both sides, and equally serrated. It abounds on the banks of the Wolga and the Tanais. 7. The Indica, or Indian mulberry, has ovate oblong leaves, equal on both sides, but unequally serrated.

The last three species are tender plants in this country; but the four first are very hardy, and succeed in any common soil and situation. The leaves are generally late before they come out, the buds seldom beginning to fill till the middle or towards the latter end of May, according to the temperature of the season; and when these trees, in particular, begin to expand their foliage, it is a good sign of the near approach of fine warm settled weather; the white mulberry, however, is generally forwarder in leafing than the black.

Considered as fruit-trees, the nigra is the only proper sort to cultivate here; the trees being not only the most plentiful bearers, but the fruit is larger and much finer-flavoured than that of the white kind, which is the only other sort that bears in this country. The three next species are chiefly employed to form variety in our ornamental plantations; though abroad they are adapted to more useful purposes. The wood of the mulberry-tree is yellow, tolerably hard, and may be applied to various uses in turnery and carving: but in order to separate the bark, which is rough, thick, thready, and fit for being made into ropes, it is proper to steep the wood in water.

Mulberry-trees are noted for their leaves affording the principal food of that valuable insect the silkworm. The leaves of the alba, or white species, are preferred for this purpose in Europe; but in China where the best silk is made the worms are said to be fed with those of the morus tartarica. The advantages of white mulberry-trees are not confined to the nourishment of worms: they may be cut every three or four years like sallows and poplar trees, to make faggots; and the sheep eat their leaves in winter, before they are burnt. This kind of food, of which they are extremely fond, is very nourishing; it gives a delicacy to the flesh, and a fineness and beauty to the wool.

The papyrifera, or paper-mulberry, is so called from the paper chiefly used by the Japanese being made of the bark of its branches. The leaves of this species also serve for food to the silkworm, and it is now cultivated with success in France. It thrives best in sandy soils, grows faster than the common mulberry, and at the same time is not injured by the cold. M. de la Bouviere affirms that he procured a beautiful vegetable silk from the bark of the young branches of this species of mulberry, which he cut while the tree was in sap, and afterwards beat and steeped. The women of Louisiana procure the same kind of production from the shoots which issue from the stock of the mulberry, and which are four or five feet high. After taking off the bark, they dry it in the sun, and then beat it that the external part may fall off; and the internal part, which is fine bark, remains entire. This is again beaten, to make it still finer: after which they bleach it with dew. It is then spun, and various fabrics are made from it, such as nets and fringes: they even sometimes weave it and make it into cloth. The finest sort of cloth among the inhabitants of Otaheite and others of the South Sea islands, is made of the bark of this tree.

The tinctoria is a fine timber-tree, and a principal ingredient in most of our yellow dyes, for which it is chiefly imported into Europe. The berries are sweet and

wholesome; but not much used, except by the winged tribe, by whose care it is chiefly planted.

MOSAIC, or *mosaic-work*, an assemblage of little pieces of glass, marble, precious stones, &c. of various colours, cut square and cemented on a ground of stucco, in such a manner as to imitate the colours of painting.

MOSCHUS, musk, a genus of quadrupeds of the order pecora: the generic character is, horns none; front teeth in the lower jaw eight, tusks solitary, in the upper jaw exserted.

1. Moschus moschiferus, Tibetian musk. The musk is one of those quadrupeds whose true form and natural history appear to have continued in great obscurity long after the introduction and general use of the celebrated perfume which it produces. To the ancients it was unknown, and was first mentioned by the Arabians, whose physicians used the drug in their practice. The animal was by some considered as a kind of goat, by others as a species of deer or antelope, and was, of course, supposed to be a horned animal; nor was it till about the decline of the seventeenth century that a tolerably accurate description or figure was to be found.

The size and general appearance of this animal resemble those of a small roebuck. It measures about three feet three inches in length, about two feet three inches in height from the top of the shoulders to the bottom of the fore-feet, and two feet nine inches from the top of the haunches to the bottom of the hind feet. The upper jaw is considerably longer than the lower, and is furnished on each side with a curved tusk about two inches long. These tusks are of a different form from those of any other quadruped; being sharp-edged on their inner or lower side, so as to resemble, in some degree, a pair of small crooked knives: their substance is a kind of ivory, as in the tusks of the babyrussa and some other animals.

The general colour of the whole body is a kind of deep iron-grey; the tips of the hairs being of a feruginous cast, the remainder blackish, growing much paler or whitish towards the roots. See Plate XCI. Nat. Hist. fig. 270.

The female is smaller than the male, and wants the tusks; it has also two small teats.

They are hunted for the sake of their well-known perfume: which is contained in an oval receptacle about the size of a small egg, hanging from the middle of the abdomen, and peculiar to the animal. This receptacle is found constantly filled with a soft, unctuous, brownish substance, of the most powerful and penetrating smell; and which is no other than the perfume in its natural state. As soon as the animal is killed, the hunters cut off the receptacle or musk-bag, and tie it up ready for sale. The animals must of necessity be extremely numerous in some parts, since we are assured by Tavernier, the celebrated merchant and traveller, that he purchased, in one of his Eastern journeys, no less than seven thousand six hundred and seventy-three musk-bags.

So violent is the smell of musk, when fresh-taken from the animal, or from quantities put up by the merchants for sale, that it has been known to force the blood from the nose, eyes, and ears, of those who have imprudently inhaled its vapours.

As musk is an expensive drug, it is frequently adulterated by various substances; and we are assured that pieces of lead has been found in some of the receptacles, inserted in order to increase the weight. The smell of musk is so remarkably diffusive, that every thing in its neighbourhood becomes strongly infected with it; even a silver cup that has had musk in it does not part with the scent, though other odours are in general very readily discharged from metallic substances.

As a medicine it is held in high estimation in the Eastern countries, and has now been introduced into pretty general use among ourselves, especially in those disorders which are commonly termed nervous; and in convulsive and other cases, it is often exhibited in pretty large doses with great success.

2. Moschus Indicus, or the Indian musk. This species is said to be rather larger than the common or Tibetian musk, of the colour mentioned in the specific character, with the head shaped like that of a horse, upright oblong ears, and slender legs. It is a native of India.

3. Moschus pygmæus, or the pygmy musk, is considerably smaller than a domestic cat, measuring little more than nine inches from the nose to the tail. Its colour is bright bay, white beneath and on the insides of the thighs. Its shape is beautiful, and the legs are so slender as not to exceed the diameter of a swan-quill; the head is rather large, and the aspect mild. It is a native of many parts of the East Indies and the Indian islands, and is said to be most common in Java, where the natives catch great numbers in snares, and carry them to the markets in their cages for sale. According to Mr. Pennant they may be purchased at so low a rate as two pence halfpenny a piece. There are three other species.

MOSQUE, a temple or place of religious worship among the Mahometans.

All mosques are square buildings, generally built with stone; before the chief gate there is a square court, paved with white marble, and low galleries round it, whose roof is supported by marble pillars. In these galleries the Turks wash themselves before they go into the mosque. In each mosque there are a great number of lamps; and between these hang many crystal rings, ostriches' eggs, and other curiosities, which, when the lamps are lighted, make a fine show. As it is not lawful to enter the mosques with shoes or stockings on, the pavements are covered with pieces of stuff sewed together, each being wide enough to hold a row of men kneeling, sitting, or prostrate. The women are not allowed to enter the mosques, but stay in the porches without. About every mosque there are six high towers, called minarets, each of which has three little open galleries, one above another: these towers, as well as the mosques, are covered with lead, and adorned with gilding and other ornaments; and from thence, instead of a bell, the people are called to prayer by certain officers appointed for that purpose. Most of the mosques have a kind of hospital belonging to them, in which travellers, of what religion soever, are entertained during three days. Each mosque has also a place called tarbe, which is the burying-place of its founders; within which is a tomb six or seven feet long, covered with green velvet or sattin, at the ends of which are two tapers, and round it several seats for those who read the koran, and pray for the souls of the deceased.

MOSS. See MUSCUS.

MOTACILLA, the *wagtail* and *warbler*, a genus of birds of the order of passeres, distinguished by a straight

weak bill of a subulated figure, a tongue lacerated at the end, and very slender legs.

1. The alba, or white wagtail, frequents the sides of ponds and small streams, and feeds on insects and worms. The head, back, and upper and lower side of the neck as far as the breast, are black; in some the chin is white, and the throat marked with a black crescent; the breast and belly are white. The tail is very long, and always in motion. Mr. Willughby observed, that this species shifts its quarters in the winter, moving from the north to the south of England during that season. In spring and autumn it is a constant attendant on the plough, for the sake of the worms thrown up by that instrument.

2. The flava, or yellow wagtail, migrates in the north of England, but in Hampshire continues the whole year. The male is a bird of great beauty; the breast, belly, thighs, and vent-feathers, being of a most vivid and lovely yellow. The colours of the female are far more obscure than those of the male: it wants also those black spots on the throat.

3. The regulus, or gold-crested wren, is a native of Europe, and of the correspondent latitudes of Asia and America. It is the least of all the European birds, weighing only a single drachm. Its length is about four inches and a half, and the wings when spread out measure little more than six inches. On the top of its head is a beautiful orange-coloured spot, called its crest, which it can hide at pleasure; the margins of the crest are yellow, and it ends in a pretty broad black line; the sides of the neck are of a beautiful yellowish-green; the eyes surrounded with a white circle; the neck and back of a dark green mixed with yellow. In America it associates with the titmice, running up and down the bark of lofty oaks with them, and collecting its food in their company, as if they were all of one brood. It feeds on insects lodged in the winter dormitories in a torpid state. It is said to sing very melodiously.

4. The sutoria, or taylor-bird, is a native of the East Indies. It is remarkable for the art with which it makes its nest, seemingly in order to secure itself and its young, in the most perfect manner possible, against all danger from voracious animals. It picks up a dead leaf, and sews it to the side of a living one: its slender bill is the needle, and its thread is formed of some fine fibres; the lining is composed of feathers, gossamer, and down. The colour of the bird is light yellow; its length three inches, and its weight only three-sixteenths of an ounce; so that the materials of the nest and its own size are not likely to draw down a habitation depending on so slight a tenure.

5. The lucinia, or nightingale, exceeds in size the hedge-sparrow. The bill is brown; the irides are hazel; the head and back pale tawny, dashed with olive; the tail is of a deep tawny red; the under parts pale ash-colour, growing white towards the vent; the quills are cinereous brown. The male and female are very similar. This bird, the most famed of the feathered tribe for the variety, length, and sweetness of its notes, is supposed to be migratory. It is met with in Siberia, Sweden, Germany, France, Italy, and Greece. Hasselquist speaks of it as being in Palestine, and Fryer ascertains its being found about Chulminor in Persia; it is also spoken of as a bird of China, Kamtschatka, and Japan; at which last place they are much esteemed, and sell dear; as they are also at Aleppo, where they are "in great abundance kept tame in houses, and let out at a small rate to such as choose it in the city, so that no entertainment is made in the spring without a concert of these birds."

They are solitary birds, never uniting into even small flocks; and in respect to the nests, it is very seldom that two are found near each other. The female builds in some low bush or quickset edge, well covered with foliage, for such only this bird frequents; and lays four or five eggs of a greenish-brown. The nest is composed of dry leaves on the outside, mixed with grass and fibres, lined with hair or down within, though not always alike. The female alone sits on and hatches the eggs, while the male not far off regales her with his delightful song; but as soon as the young are hatched, he commonly leaves off singing, and joins with the female in the task of providing for and feeding them. After the young can provide for themselves, the old female provides for a second brood, and the song of the male recommences. They have been known to have three broods in a year, and in the hot countries even four. These birds are often brought up from the nest for the sake of their song. They are likewise caught at their first coming over; and though old birds, yet by management can be made to bear confinement, and to sing equally with those brought up from the nest. None but the vilest epicure, as Mr. Latham remarks, would think of eating these charming songsters; yet we are told that their flesh is equal to that of the ortolan, and they are fatted in Gascony for the table.

6. The modularis, or hedge-sparrow, a well-known bird, has the back and wing-coverts of a dusky hue, edged with reddish-brown; rump of a greenish-brown; throat and breast of a dull ash-colour; the belly a dirty white; and the legs of a dull flesh-colour. The note of this bird would be thought pleasant, did it not remind us of the approach of winter; beginning with the first frosts, and continuing till a little time in spring. Its often repeating the word tit, tit, tit, has occasioned its being called titling; a name it is known by in many places.

7. The phœnicurus, or redstart, is somewhat less than the redbreast; the forehead is white; the crown of the head, hind part of the neck, and back, are deep blue-grey; the cheeks and throat black; the breast, rump, and sides, red; and the belly is white; the two middle tail-feathers are brown; the rest red; and the legs are black. The wings are brown in both sexes.

This bird is migratory; coming hither in spring, and departing in autumn about October. It is not so shy as many birds in respect to itself; for it approaches habitations, and frequently makes its nest in some hole of a wall where numbers of people pass by frequently; yet it is content, if no one meddles with the nest. This bird frequently wags its tail; but does it sideways, like a dog, when he is pleased, and not up and down like the wagtail. It is with difficulty that these birds are kept in a cage; nor will they submit to it by any means if caught old. Their song has no great strength; yet it is agreeable enough; and they will, if taught young, imitate the notes of other birds, and sing by night frequently as well as in the day-time.

8. The rubecula, or redbreast, is universally known.

It abounds in Burgundy and Lorraine, where numbers are taken for the table, and thought excellent. It builds not far from the ground if in a bush; though sometimes it fixes on an out-house, or retired part of some old building. The nest is composed of dried leaves, mixed with hair and moss, and lined with feathers. The eggs are of a dusky white, marked with irregular reddish spots; and are from three to seven in number. The young, when full-feathered, may be taken for a different bird, being spotted all over. The first rudiments of the red break forth on the breast about the end of August, but it is quite the end of September before they come to the full colour. Insects are their general food; but in defect of these they will eat many other things. No bird is so tame and familiar as this; closely attending the heels of the gardener when he is using his spade, for the sake of worms; and frequently in winter entering houses where windows are open, when they will pick up the crumbs from the table while the family is at dinner. Its familiarity has caused a petty name to be given it in several countries. The people about Bornholm call it Tommi-liden; in Norway, Peter-ronsmad; the Germans, Thomas-gierdet; and we, the Robin-red-breast.

9. The œnanthe, or wheatear, is in length five inches and a half. The top of the head, hind part of the neck, and back, are of a blueish grey; and over the eye a streak of white; the under parts of the body yellowish-white: the breast is tinged with red; and the legs are black. This bird is met with in most parts of Europe, even as far as Greenland: and specimens have also been received from the East Indies. It visits England annually in the middle of March, and leaves us in September. It chiefly frequents heaths. The nest is usually placed under shelter of some turf, clod, stone, or the like, always on the ground, and not unfrequently in some deserted rabbit-burrow. It is composed of dry grass or moss, mixed with wool, fur of the rabbit, &c. or lined with hair and feathers. The eggs are from five to eight in number, of a light blue, with a deeper-blue circle at the large end. The young are hatched the middle of May. In some parts of England these birds are in vast plenty. About Eastbourn in Sussex they are taken in snares made of horse-hair placed beneath a long turf: being very timid birds, the motion of a cloud, or the appearance of a hawk, will drive them for shelter into these traps, and so they are taken. The numbers annually ensnared in that district alone amount to about 1840 dozen, which usually sell at sixpence per dozen. Quantities of these are eaten on the spot by the neighbouring inhabitants; others are picked, and sent up to the London poulterers; and many are potted, being as much esteemed in England as the ortolan on the continent. Their food is insects only; though in rainy summers they feed much on earth-worms, whence they are fattest in such seasons.

10. The cyanea, or superb warbler, a most beautiful species, is five inches and a half long. The bill is black; the feathers of the head are long, and stand erect like a full crest; from the forehead to the crown they are of a bright blue; thence to the nape, black like velvet; through the eyes from the bill there runs a line of black; and beneath the eye springs a tuft of the same blue feathers; beneath which, and on the chin, it is of a deep blue, almost black, and feeling like velvet. The hind part of the neck, and upper parts of the body and tail, are of a deep blue-black, the under pure white; the wings are dusky; the shafts of the quills chesnut; the legs are dusky brown; the claws black. It inhabits Van Diemen's Land, the most southern part of New Holland. The female of this species, is discovered to be entirely destitute of all the fine blue colours, both pale and dark, by which the male is adorned, except that there is a very narrow circle of azure round each eye, apparently on the skin only.

11. The troglodytes, or wren, is a very small species, in length only three inches and three quarters, though some have measured four inches. It generally carries the tail erect. This minute bird is found throughout Europe; and in England it defies our severest winters. Its song is much esteemed, being, though short, a pleasing warble, and much louder than could be expected from the size of the bird; it continues throughout the year.

The sylvia builds in low bushes, and lays five pale-green eggs, sprinkled with reddish spots. See Plate XCI. Nat. Hist. fig. 271.

Above 150 other species, besides varieties, are enumerated by ornithologists.

MOTE, in law-books, signifies court, meeting, or convention, as a ward-mote, burgh-mote, swain-mote, &c.

MOTH. See PHALENA.

MOTION, has been defined to be "a change of place," or the act by which a body corresponds with different parts of space at different times.

We are principally acquainted with two sorts of motion in the beings that surround us; one is the motion by which an entire body is transferred from one place to another, as that of a stone when it falls, or of a ship under sail. It is this species of motion which most frequently comes under our observation, and with which we are best acquainted. But besides this, there is another kind of motion, which, though not so obvious, is yet not less common nor important. This is a motion of the parts of bodies among themselves, which though sometimes the object of our senses, yet in other cases we require the aid of reflection to be convinced of its existence. It is by this imperceptible motion that plants and animals grow, and by which the greatest number of the compositions and decompositions throughout the globe take place. We may form some idea of this, by observing the continual motion of the light particles which sometimes float about in water, when it is held in the rays of the sun, which proves, that the parts of the water themselves are in constant motion. But if we reflect a little, we shall discover that the particles of the most solid bodies are also continually changing their situations. Heat expands, and cold contracts, the size of all bodies; now, we know from experience, that the temperature of bodies is constantly varying, consequently, the particles must be in continual agitation, in order to adapt themselves to the size of the body.

The communication of motion from one body to another, though a fact with which we are well acquainted, we are equally incapable of accounting for. It is, however, of the utmost importance in mechanics, which is indeed an art derived from the study of its laws. In considering motion, several circumstances must be attended to:

1. The force which impresses the motion. 2. The

quantity of matter in the moving body. 3. The velocity and direction of the motion. 4. The space passed over by the moving body. 5. The time employed in going over this space. 6. The force with which it strikes another body that is opposed to it.

In a mechanical sense, every body, by its inertia, resists all change of state. If at rest, it will not begin to move of itself; and if motion is communicated to it by another body, it will continue to move for ever uniformly, except it is stopped by an external agent. It is true, we do not see any instances of bodies continuing to move for ever, after being once put in motion; but the reason of this is, that all the bodies which we see are acted upon in such a manner, as to have their motion gradually destroyed by friction, or the rubbing of other bodies upon them. For if you diminish the friction by any means, the motion will continue much longer; but as it is impossible to destroy it entirely, it diminishes, and at last destroys, all motions on the surface of the earth. To put a body in motion, therefore, there must be a sufficient cause. These causes are called motive powers, and the following are those generally used in mechanics; the action of men and other animals, wind, water, gravity, the pressure of the atmosphere, and the elasticity of fluids and other bodies.

The velocity of motion is estimated by the time employed in moving over a certain space, or by the space moved over in a certain time. To ascertain the degree of this swiftness or velocity, the space run over must be divided by the time. For example: suppose a body moves over 1000 yards in 10 minutes, its velocity will be 100 yards per minute. If we would compare the velocity of two bodies A and B, of which A moves over 54 yards in 9 minutes, and B 96 yards in 6 minutes, the velocity of A will be to that of B, in the proportion of 6 (the quotient of 54 divided by 9) to 16 (the quotient of 96 divided by 6).

To know the space run over, the velocity must be multiplied by the time; for it is evident, that if either the velocity or the time is increased, the space run over will be greater. If the velocity is doubled, then the body will move over twice the space in the same time; or if the time is twice as great, then the space will be doubled; but if the velocity and time are both doubled, then will the space be four times as great.

It follows from this, that when two bodies move over unequal spaces in unequal times, their velocities are to each other as the quotients arising from dividing the spaces run over by the times. If two bodies move over unequal spaces in the same time, their velocities will be in proportion to the spaces passed over. And if two bodies move over equal spaces in unequal times, then their respective velocities will be inversely as the time employed; that is, if A in one minute, and B in two minutes, run over 100 yards, the velocity of A will be to that of B as 2 to 1.

A body in motion must every instant tend to some particular point. It may either tend always to the same point, in which case the motion will be in a straight line; or it may be continually changing the point to which its motion is directed, and this will produce a curvilinear motion.

If a body is acted upon only by one force, or by several in the same direction, its motion will be in the same direction in which the moving force acts; as the motion of a boat which a man draws to him with a rope. But if several powers, differently directed, act upon it at the same time, as it cannot obey them all, it will move in a direction somewhere between them.

This is what is called the composition and resolution of motion, and is of the utmost importance in mechanics.

Suppose a body A (Plate XCIV. Miscel. fig. 163) to be acted upon by another body in the direction AB, while at the same time it is impelled by another in the direction AC, then it will move in the direction AD; and if the lines AB, AC, are made of lengths proportionate to the forces, and the lines CD, DB, drawn parallel to them, so as to complete the parallelogram ABDC, then the line which the body A will describe, will be the diagonal AD; and the length of this line will represent the force with which the body will move. It is evident, that if a body is impelled by equal forces acting at right angles to each other, that it will move in the diagonal of a square; but whatever may be the direction, or degree of force by which the two powers act, the above method will always give the direction and force of the moving body.

It follows from this, that if we know the effect which the joint action of two powers has upon a body, and the force and direction of one of them, it is easy to find that of the other. For, suppose AD to be the direction and force with which the body moves, and AB to be one of the impelling forces, then, by completing the parallelogram, the other power AC is found.

Instances in nature of motion produced by several powers acting at the same time, are innumerable. A ship impelled by the wind and tide is one well known. A paper kite, acted upon by the wind and the string, is another.

Motion is said to be accelerated, if its velocity continually increases; to be uniformly accelerated, if its velocity increase equally in equal times.

Motion is said to be retarded, if its velocity continually decreases: and to be uniformly retarded, if its velocity decreases equally in equal times.

If you suppose a body to be put in motion by a single impulse, and moving uniformly, to receive a new impulse in the same direction, its velocity will be augmented, and it will go on with the augmented velocity.

If at each instant of its motion it receives a new impulse, the velocity will be continually increasing; and if this impulse is always equal, the velocity will be uniformly accelerated.

The regularly increasing velocity with which a body falls to the earth, is an instance of accelerated motion, which is caused by the constant action of gravity. To illustrate this, let us suppose the time of descent of a falling body to be divided into a number of very small equal parts; the impression of gravity, in the first small instant, would make the body descend with a proportionate and uniform velocity; but in the second instant, the body receiving a new impulse from gravity, in addition to the first, would move with twice the velocity as before; in the third instant, it would have three times the velocity, and so on.

To illustrate the doctrine of accelerated motion, let us suppose that, in the triangle ABC (fig. 164),

AB expresses the time which a body takes to fall, and BC the velocity acquired at the end of the fall. Let AB be divided into a number of equal parts, indefinitely small, and from each of these divisions suppose lines, as DE, drawn parallel to BC; it is evident from what has been said, that those lines will express the velocities of the falling body in the several respective points of time, each being greater than the other, by a certain quantity of increase, which follows from the nature of the triangle. Now, the spaces described in the same time, are in proportion to the velocities; and the sum of the spaces described in all the small portions of time, is equal to the space described from the beginning of the fall. But the sum of all the lines parallel to BC, taken indefinitely near to each other, constitutes the area of the triangle. Therefore the space described by a falling body, in the time expressed by AB, with an uniformly accelerated velocity, of which the last degree is expressed by BC, will be represented by the area of the triangle ABC.

Let us now suppose that gravity ceased to act, and that the body moved during another portion of time, BF, equal to AB, with the acquired velocity represented by BC. As the space moved over is found by multiplying the velocity by the time, the rectangle CF will represent the space moved over in this second portion of time, which is twice the triangle ABC, and consequently twice the space is moved over with the accelerating velocity in the same time.

But if we suppose gravity still to act, besides the space CF, which it would have moved over by its acquired velocity, we must add the triangle CGH, for the effect of the constant action of gravity; therefore, in this second portion of time, the body moves over three times the space as in the first. In like manner it may be easily seen by the figure, that in the next portion it would move over five times the space; in the next seven times, and so on, in arithmetical progression. And as the velocities of falling bodies are in proportion to the spaces run over, it follows, that the velocities in each instant increase, as the numbers 1, 3, 5, 7, 9, &c.

It follows from this, that the space run over is as the square of the time; that is, in twice the time, a body will fall with four times the velocity; in thrice the time, with nine times the velocity, &c. for, in the first time, there was but one space run over; the square of 1 is 1: at the end of the second time there are four spaces run over, one in the first, and three in the second; the square of 2 is 4; at the end of the third time there are nine spaces run over; the square of 3 is 9: and so on. This may be seen in the figure.

It is found by experiment, that a body falling from a height, moves at the rate of $16\frac{1}{12}$ feet in the first second; and, as has been shown above, acquires a velocity of twice that, or $32\frac{1}{6}$ feet in a second. At the end of the next second, it will have fallen $64\frac{1}{3}$ feet, the space being as the square of the time; the square of 2 is 4, and 4 times $16\frac{1}{12}$ is $64\frac{1}{3}$. By the same rule you may find, that in the third second it will fall 144 feet; and in the next 256 feet, and so on. It is to be understood, however, that by this velocity is meant what bodies would acquire, if they were to fall through a space where there was no air; for its resistance considerably diminishes their velocity in falling.

It has been already shown, that if two forces act uniformly upon a body, they will cause it to move in a straight line; but if one of the forces is not uniform, but either accelerating or retarding, the moving body will describe a curve line. If a ball is projected from a cannon, it receives from it an impulse, which, if there was no resistance from the air, and if it was not acted upon by gravity, would cause it to move always in a straight line; but as soon as it leaves the mouth of the cannon, gravity acts upon it, and makes it change its direction. It then describes a curve, called a parabola. This is the foundation of the theory of projectiles, and the art of gunnery; but it is not now considered to be of so much importance as it formerly was, as it is found that the resistance of the air, and other causes, have so much effect upon projected bodies, that they describe curves very different from what they ought to do according to this theory; and therefore it is much less applicable to practice than otherwise it would be.

The force with which a body moves, or which it would exert upon another body opposed to it, is always in proportion to its velocity multiplied by its weight, or quantity of matter. This force is called the momentum of the body: for if two equal bodies move with different velocities, it is evident that their forces, or momenta, are as their velocities; and if two bodies move with the same velocity, their momenta are as the quantities of matter; therefore, in all cases, their momenta must be as the products of their quantities of matter, and their velocities. This rule is the foundation of mechanics.

In consequence of the vis inertiæ of matter, all motion produced by one force only acting upon a body, must be rectilinear; for it must receive some particular direction from the power that impressed it, and must retain that direction until it is changed by some other power. Whenever, therefore, we see a body moving in a curvilinear direction, we may be certain that it is acted upon by two forces at least. When one of the two forces ceases to act, the body will move again in a straight line. Thus a stone in a sling is moved round by the hand, while it is pulled towards the centre of the circle, which it describes, by the string: but when the string is let go, the stone flies off in a tangent to the circle.

Every body moved in a circle has a tendency to fly off from its centre, which endeavour of receding is called the centrifugal force: and it is opposed to the centripetal force; or that which, by drawing bodies towards the centre, makes them revolve in a curve. These two forces are called together central forces.

The centre of gravity of a body is that point about which all the parts of a body do in any situation exactly balance each other.

Hence, if a body is suspended or supported by this point, the body will rest in any position in which it is put. Also, whatever supports that point bears the weight of the whole body; and while it is supported, the body cannot fall. We may therefore consider the whole weight of a body as centred in this point.

The common centre of gravity of two or more bodies is the point about which they would equiponderate, or rest, in any position. If the centre of gravity of two bodies, A and B, (Plate XCIV. Miscel. fig. 165) is con-

nected by the right line AB, the distances AC and BC, from the common centre of gravity C, are reciprocally as the weights of the bodies A and B, that is, AC : BC : B : A.

If a line is drawn from the centre of gravity of a body, perpendicular to the horizon, it is called the line of direction; because it is the line that the centre of gravity would describe if the body fell freely.

It is the property of this line, that while it falls within the base upon which the body stands, the body cannot fall; but if it fall without the base, the body will tumble. Thus the inclining body ABCD, (fig. 166) whose centre of gravity is E, stands firmly on its base CDIK, because the line of direction EF falls within the base. But if a weight, as ABGH, is laid upon the top of the body, the centre of gravity of the whole body and weight together is raised to L; and then, as the line of direction LD falls without the base at D, the centre of gravity is not supported, and the whole body and weight will tumble down together.

Hence appears the absurdity of people's rising hastily in a coach or boat, when it is likely to overset; for by that means they raise the centre of gravity so far as to endanger throwing it quite out of the base, and if they do, they overset the vehicle effectually. Whereas, had they clapped down to the bottom, they would have brought the line of direction, and consequently the centre of gravity, farther within the base, and by that means might have saved themselves.

The broader the base, and the nearer the line of direction is to the middle or centre of it, the more firmly does the body stand. On the contrary, the narrower the base, and the nearer the line of direction is to the side of it, the more easily may the body be overthrown, a less change of position being sufficient to remove the line of direction out of the base in the latter case than in the former. And hence it is, that a sphere is so easily rolled upon a horizontal plane; and that it is so difficult, if not impossible, to make things which are sharp pointed to stand upright on the point.

From what has been said, it plainly appears, that if a plane CD on which a heavy body is placed, was elevated at C, the body would slide down upon the plane, whilst the line of direction falls within the base; but it would tumble or roll down when that line falls without the base. Thus the body E (fig. 167) would only slide down, whilst the body B would roll down upon it.

When the line of direction falls within the base of our feet, we stand, and most firmly when it is in the middle; but when it is out of that base, we immediately fall. And it is not only pleasing, but even surprising, to reflect upon the various methods and postures which we use, to retain this position, or to recover it when lost, without our being sensible of it. Thus we bend our bodies when we rise from a chair, or when we go up stairs; and for this purpose a man leans forward when he carries a burden upon his back, and backward when he carries it on his breast, and to the right or left side as he carries it on the opposite side.

If a body is suspended freely from different centres, its centre of gravity will be in the intersection formed by lines drawn from those centres perpendicular to the horizon. Hence we obtain an easy practical method of finding the centre of gravity of any irregular plane figure. Suspend it by any point, with the plane perpendicular to the horizon, and from the point of suspension hang a plumb line, and draw a line upon the body where the string passes over; do the same for any other point of suspension, and where the two lines meet must be the centre of gravity; for the centre of gravity being in each line, it must be at the point where they intersect.

Motion, *spontaneous* or *muscular*, is that performed by the muscles at the command of the will.

Motion, *natural* or *involuntary*, that effected, without any such command, by the mere mechanism of the parts, such as the motion of the heart, pulse, &c.

Motion, *intestine*, the agitation of the particles of which a body consists.

Motion, in music, the manner of beating the measure, to hasten or slacken the time of the words or notes.

MOVEMENT, in mechanics, a machine that is moved by clockwork. See Clockwork.

MOULDINGS. See Architecture.

MOUNTAINS. Elevations consisting chiefly of clay, sand, or gravel, are called hills. Those which consist chiefly of stone are called mountains. Mountains are divided into primæval, that is, of equal date with the formation of the globe, and secondary or alluvial. Among primæval, those of granite hold the first place. The highest mountains and most extensive ridges throughout the globe are of that kind; as the Alps and Pyrenees in Europe; the Altnischan, Uralian, and Caucasus, in Asia, and the Andes, in America. The highest of them never contain metallic ores; but some of the lower contain ores of copper and tin. The granite next the ore always abounds in mica. Petrifactions are never found in these primæval mountains.

That the formation of these mountains preceded that of vegetables and animals, is justly inferred from their containing no organic remains, either in the form of petrifaction or impression. Naturalists are agreed, that granites were formed by chrystallization. This operation probably took place after the formation of the atmosphere, and the gradual excavation of the bed of the ocean, when the dry land appeared. For, by means of the separation of the aeriform fluids which constitute the atmosphere, the evaporation of part of the water into the atmosphere, and the gradual retreat of the remainder, the various species of earths, before dissolved or diffused through this mighty mass, were disposed to coalesce; and among these the siliceous must have been the first, as it is the least soluble; but as the siliceous earth has an affinity to the other earths with which it was mixed, some of these must have united in various proportions, and thus have formed, in distinct masses, the feldtspar, schorl, and mica, which compose the granite. Calcareous earth enters very sparingly into the composition of this stone; but as it is found in schorl, which is frequently a component part of granite, it follows that it must be one of the primitive earths, and not entirely derived from marine exuviæ, as some have supposed. Quartz can never be supposed to be a product of fire; for in a very low heat it bursts, cracks, and loses its transparency, and in the highest degree of heat that we can produce, is infusible, so that in every essential point it is different from glass,

to which some have compared it. As granite contains earths of every genus, we may conclude, that all the simple earths are original. This, however, is no proof that they are in reality simple and uncompounded of other principles; but they must be considered as such in the present state of our knowledge. Though water undoubtedly dates from creation, yet late experiments have shown it to be a compound, as was formerly stated.

Mountains which consist of limestone or marbles of a granular or scaly texture, and not disposed in strata, seem also to have preceded the creation of animals, for no organic traces are found in them. Some of those which consist of argillaceous stones, and some of the siliceous, contain also no organic remains. These often consist of parallel strata of unequal thickness; and the lower are harder and less thick than the upper, and therefore seem to have been formed earlier than the upper.

Alluvial mountains are evidently of posterior formation, as they contain petrifactions and other vestiges of organic substances, and these are always stratified.

Mountains, as to structure, are entire, stratified, and confused. Entire mountains are formed of huge masses of stone, without any regular fissures, and are mostly homogeneous. They consist chiefly of granite, sometimes gneiss, schistus, flag-stone, sand-stone, lime-stone, gypsum, porphyry, or trap. Some in Sweden and Norway consist of iron-ore.

The stratified mountains are those whose mass is regularly divided by joints or fissures: these are called horizontal, rising, or dipping. Homogeneous stratified mountains consist chiefly of stones of the argillaceous genus, or of the fissile compound species of the siliceous genus, as metallic rock; sometimes of limestone of a granular or scaly texture, in which no animal vestiges appear. This limestone reposes on the argillaceous or siliceous strata: sometimes the argillaceous are covered with masses of granite, sometimes of lava. These mountains, particularly those of gneiss, metallic rock, and horn-stone, are the chief seat of metallic ores. When covered with lime-stone, the ore is generally between the lime-stone and the argillaceous stones. These ores run in veins, not in strata. Petrifactions are found upon, but not in, these mountains.

Heterogeneous, or compound stratified mountains, consist of alternate strata of various species of stones, earths, sands, &c. The limestone here is always of the laminar, and not of the granular or scaly, kind; and when it contains any ore, it is placed between its laminæ. Stones of the siliceous genus seldom form strata in these mountains, except lavas; but the strata are frequently interrupted by siliceous masses, as jasper, porphyry, &c. Coal, bitumen, petrifactions, and organic impressions, are found in these mountains; also salts and calamine.

There are other mountains, which cannot properly be called stratified, as they consist only of three immense masses, the lowest granite, the middle argillaceous, and the upper limestone. Metallic ores are found in the argillaceous part, between it and the limestone.

Confused mountains consist of stones heaped together without order, their interstices filled with clay, sand, and mica. They scarcely ever contain any ore.

Besides these, there are many mountains in different parts of the world, which derive their origin from volcanoes; but of these it will be necessary to treat in a succeeding article.

The height of mountains is usually calculated by means of the barometer. For this purpose two columns of mercury, or barometers, are provided, and one is kept at the foot of the mountain while the other is carried to its summit. The degree of heat, if not equal, is reduced by calculation to an equality, and for this purpose a thermometer is attached to each of the barometers. The degree of heat to which both are reduced, is 55°: if, however, either of the barometer stands at 30 inches, and the annexed thermometer at 55°, no reduction is to be made in the degrees indicated by that barometer; but if either of them is at 30°, and the thermometer below 55°, we must add the expansion the mercury in the barometer would have experienced at the heat of 55°. If the heat should, on the contrary, be above 55°, we must abstract the degree of expansion which it gains by that heat. Every degree of Fahrenheit's scale produces an expansion of 00.304 of the barometrical inch, when the barometer is at 30; when, therefore, the thermometer is at 11° below or above 55°, we must add in the former, or subtract in the latter case, eleven times that number from the barometrical height. In the same manner it may be calculated, whatever is the height of the barometer. When this matter is ascertained, the height is easily found by comparing the two barometers, and calculating the density of the air in the higher regions according to the principles of geometrical progression.

The highest mountains are those which are situated at or near the equator; and the Andes are generally allowed to be the highest of these. Catopaxi, one of the Andes, which was measured by Ulloa and the French academicians, was found to be some miles above the level of the sea; whereas the highest point of the Alps is not above a mile and a half. Mount Caucasus approaches nearest to the height of the Andes, of any of the Asiatic mountains. The Peak of Teneriff, which has been so much celebrated, is about a mile and a half in height. It is an extraordinary circumstance, that the moon, which is a body so much smaller than our earth, should have been thought to exceed it in the irregularities of its surface; some of the mountains in that planet being formerly supposed to exceed nine miles in height: but Dr. Herschel has proved that the highest of them is not equal to one mile.

The line of congelation, or of perpetual frost, on mountains, is calculated at 15,400 feet, at or near the equator; at the entrance of the temperate zone, at 13,428; on Teneriff, at 10,000; in Auvergne (lat. 45) 6,740; with us (lat. 52) 5,740. On the Andes, vegetation ceases at 14,697 feet; and on the Alps, at 9,585. The air is so dry in these elevated situations, that M. d'Arcet observed, that on the Pic de Midi, one of the Pyrenees, salt of tartar remained dry for an hour and a half, though it immediately moistened in the same temperature at the bottom of the mountain.

MOUNTING, in military affairs, signifies going upon duty. Thus, mounting a breach, is running up to it; mounting the guard, is going upon guard; and mounting the trenches, is going upon duty in the trenches; but

mounting the cannon, mortar, &c. is the setting it on its carriage, or the raising its mouth.

MOUSE. See Mus.

MOUTH. See ANATOMY.

MUCILAGE, a glutinous matter obtained from vegetables, transparent and tasteless, soluble in water, but not in spirit of wine. It chiefly consists of carbon, hydrogen, and a small quantity of oxygen. See GLUTEN.

MUCILAGINOUS GLANDS. See ANATOMY.

MUCOR, in botany, a genus of the order of fungi, in the cryptogamia class of plants. The fungus has vesicular heads supported by footstalks. There are 17 British species; the most remarkable of which are: 1. The sphærocephalus, or grey round-headed mucor, growing upon rotten wood, and sometimes upon decayed plants and mosses. The stalks of this are generally black, about a line in height, bearing each at the top a spherical ball about the size of a pin's head; its coat or rind is covered with a grey powder, and containing within a black or fuscous spongy down. The coat bursts with a ragged, irregular margin. 2. The lichenoides, or little, black, pin-headed mucor. This species grows in groups near to each other, in chasms of the barks of old trees, and upon old park-pales. The stalks are black, about two lines in height, bearing each a single head, sometimes a double or treble one, of the size of mustard or poppy seeds, of a roundish figure at first, but when burst, often flattish or truncated, and of a black colour. The internal powdered down is black, with a tinge of green. 3. The mucedo, or common grey mould, grows on bread, fruits, plants, and other substances, in a putrid state. It grows in clusters; the stalks a quarter of an inch high, pellucid, hollow, and cylindrical; supporting each a single globular head, at first transparent, afterwards dark-grey; which bursts with elastic force, and ejects small round seeds discoverable by the microscope. 4. The glaucus, or grey cluster-headed mould, is found on rotten apples, melons, and other fruits; as also upon decayed wood, and the stalks of wheat. These are of a pellucid grey colour; the stalks are generally single, supporting a spherical ball, which, when magnified, appears to be compounded of numerous, fine, moniliform, necklace-like radii. 5. The crustaceus, or fingered mould, is frequent upon corrupted food of various kinds. It is of a white aqueous colour; the stalks single, each supporting at the top four or five necklace-like radii, diverging from the same point or centre. 6. The septicus, or yellow frothy mucor, is found on the leaves of plants, such as ivy and beech, &c. sometimes upon dry sticks, and frequently upon the tan or bark in hot-houses. It is of no certain size or figure, but of a fine yellow colour, and a substance resembling at first cream beaten up into froth. In the space of 24 hours it acquires a thin filmy coat, becomes dry, and full of a sooty powder adhering to downy threads. The seeds under the microscope appear to be globular. Haller ranks it under a new genus, which he terms fuligo; the characters of which are, that the plants contained under it are soft, and like butter at first, but soon change into a black sooty powder.

MUCOUS ACID. See SALACTIC ACID.

MUCOUS GLAND. See ANATOMY.

MUCUS, a fluid secreted by certain glands, and serving to lubricate many of the internal cavities of the body. In its natural state it is generally limpid and colourless, but from certain causes, will often assume a thick consistence and whitish colour like pus. As it is sometimes of very great importance in medicine to distinguish these two fluids from each other, this was lately proposed as the subject of a prize disputation by the Æsculapian Society of Edinburgh. The prize was gained by Mr. Charles Darwin, student of medicine from Litchfield.

The conclusions drawn from his experiments were, 1. Pus and mucus are both soluble in the vitriolic acid, though in very different proportions, pus being by far least soluble. 2. The addition of water to either of these compounds decomposes it. The mucus thus separated either swims in the mixture, or forms large flocculi in it; whereas the pus falls to the bottom, and forms, on agitation, an uniform turbid mixture. 3. Pus is diffusible through a diluted vitriolic acid, though mucus is not. The same also occurs with water, or with a solution of sea-salt. 4. Nitrous acid dissolves both pus and mucus. Water added to the solution of pus produces a precipitate, and the fluid above becomes clear and green, while water and the solution of mucus form a turbid dirty-coloured fluid. 5. Alkaline lixivium dissolves, though sometimes with difficulty, mucus, and generally pus. 6. Water precipitates pus from such a mixture, but does not mucus. 7. Where alkaline lixivium does not dissolve pus, it still distinguishes it from mucus, as it then prevents its diffusion through water. 8. Coagulable lymph is neither soluble in concentrated nor diluted vitriolic acid. 9. Water produces no change on a solution of serum in alkaline lixivium, until after long standing, and then only a very slight sediment appears. 10. Corrosive sublimate coagulates mucus, but does not pus.

From the above experiments, it appears that strong sulphuric acid, and water, diluted sulphuric acid, and caustic alkaline lixivium and water, will serve to distinguish pus from mucus; that the vitriolic acid can separate it from coagulable lymph, and alkaline lixivium from serum. Hence, when a person has any expectorated matter, the decomposition of which he wishes to ascertain, let him dissolve it in vitriolic acid, and in caustic alkaline lixivium; and let him add pure water to both solutions. If there is a fair precipitation in each, he may be assured that some pus is present. But if there is a precipitation in neither, it is a certain test that the mixture is entirely mucus. If the matter cannot be made to dissolve in alkaline lixivium by time and trituration, we have also reason to believe that it is pus.

MUCUS, NASAL: this name is given to a liquid which is secreted in the cavities of the nose, and is discharged outwardly, either by the nostrils in the form of drops, or in that of masses more or less thick; or by the fauces when it descends by the posterior part of the nasal cavities, in which it is thrown out by spitting. This liquid is separated from the blood by the arteries, and appears to be formed in particular crypts, which we find abundantly disseminated in the nostrils: it is collected also from all the frontal sinuses. It is also mixed with the lachrymal juice, which descends by the channel which passes through the os unguis, and dilutes the thickened nasal mucus.

We must particularly consider both the abundance

and the characters of this liquid in the catarrh, improperly called catarrh of the brain, in which the usual mucus is separated in large quantity, and remains a longer time in its ducts. "It is," says M. Fourcroy, "especially under this circumstance, that citizen Vauquelin and myself have examined it, as we then procured it with great facility. We have also availed ourselves of the considerable discharge of mucus which is produced by the contact of the oxygenated muriatic acid gas, in order to obtain a sufficient quantity of it for the experiments adapted for making us well acquainted with its nature. It has several times happened to citizen Vauquelin, who is very sensible to the action of the oxigenated muriatic acid gas, that he has collected by its effect 64 grammes of this liquid in less than an hour. By means of these circumstances we have been enabled to determine its nature in a considerably exact manner. It is known that this liquid is very abundant in children, that it is a little heavier than water, and adheres to most bodies, even the most polished."

The nasal mucus is at first liquid, clear and limpid, a little viscid and adhesive, without smell, of a saline and acrid taste, which irritates the most delicate part of the skin; it is then really the pituita vitrea of the ancients. When exposed to the air and to the fire, it comports itself in the same manner as the tears, from which it differs only by the abundance of its residuum, which is thicker, and frequently more coloured. It affords chrystals of muriate of soda, of soda in the state of carbonate, and of phosphates of lime and of soda: the last are much more abundant than the others. It turns paper stained with mallow-flowers green, by its salts: we also find in it an animal matter which is not albuminous, but quickly becomes thick and concrete by the oxigen of the air and of the oxigenated muriatic acid; it then acquires opacity, and a yellow or greenish colour, swells considerably, and becomes filled with bubbles by the action of fire, leaving but little residuum upon the ignited coals. This animal mucilage, which is more abundant than in the tears, appears to be of the same nature in both.

This liquid, being always exposed to the air, which continually passes through the nostrils, is constantly thicker, more viscid, and more adhesive, than the tears; and the carbonate of soda which it contains, whilst the latter contains only soda, announces that the air deposits in it a part of the carbonic acid which it contains, especially as it is expired out of the lungs. Consequently, it then renders the solutions of barytes, of strontian, and of lime, very sensibly turbid. In the nostrils, the heat of the plant, especially in catarrhs, and the current which incessantly acts upon it, contribute also to thicken it. The mucilage of the nasal humour, when it becomes thick in the air, frequently assumes in it the form of small, dry, brilliant, and, as it were, micaceous plates. If it has dryed in very thin layers, it nearly resembles those brilliant and light marks which snails leave behind them upon the substances over which they crawl. The nasal mucus experiences no real putrefaction in the air; we should almost be induced to say that it was unalterable and imputrescible, when we see it remain without contracting any bad smell, even in the midst of water, and at a considerably elevated temperature. However, this property of preservation does not extend so far as to communicate itself to other bodies that are immersed in it.

Water does not dissolve the mucus of the nose. It is known that this matter remains viscid in that fluid, and that it cannot be diluted in water without much difficulty, even by agitation. Hot water and ebullition do not render this singular mixture more miscible or more soluble. In boiling water, it appears at first to form one body with the water; nevertheless, we see it separate and fall to the bottom of this liquid by cooling. It is probable that this insolubility is owing to the fixation of the oxigen. Neither has it the property of rendering oils miscible with water, nor of affecting their suspension by trituration, as a vegetable mucilage does. It is on this account that when we wash, or even boil, this thick humour in water, the salts which it contains are dissolved and separated, without affecting the mucilage which constitutes its base.

The acids thicken the nasal mucus when they are concentrated and employed in small proportions; but when we add a larger quantity, they redissolve and give it different shades of colour. The sulphuric acid tinges it purple, and renders it very liquid, forming however some flakes in it which sink to the bottom. The nitric acid, when rather strong, dissolves it of a yellow colour. The muriatic acid is that which effects its solution the most easily and the most completely of all, giving it a violet-colour. The alkaline, or earthy salts, do not cause it to undergo any alteration, nor do they dissolve it.

The mucus of the nostrils being especially distinguished from all the other animal liquids by the viscid mucilage which it contains in considerable abundance, it is evidently from the presence of this principle that we ought to seek its uses, and the function which it performs in the animal economy. Besides the kind of evacuation, sometimes very abundant, which it procures; and the proportion of the evacuated matter compared with that of the other excretory organs, which it carries out of the body; this liquid maintains the softness of the membranous sides of the nasal cavities, and prevents that dryness which the air passing in continual streams through these cavities tends to produce in them. It moderates the too great sensibility of the nervous papillæ which are spread out upon the olfactory membrane; it stops and fixes the odorous bodies, it blunts their too great activity; it purifies the air that is respired, by taking from it the pulverulent particles which it carries along with it, and which would be more hurtful in the lungs. Being always contained in a hot, humid, and arid place, three circumstances which would so eminently promote putrefaction, provident nature has given it a property which opposes the septicity which would have exposed man and the animals to a multitude of dangerous vitiations and maladies.

It is known that the mucus of the nostrils is capable of changing its nature, and assuming various properties, in the nasal affections. It thickens, becomes yellow, orange-coloured, or greenish, frequently tinges linen with a very lively green cast by drying upon it; it sometimes produces the sensation of the presence of copper; and sometimes it exhales a nauseous or fetid smell. In some affections it become so acrid that it seems to corrode the membrane of the nostrils, and produces excoria-

tions round their orifices, as well as upon the upper lip. Lastly, it is sometimes liquid like water, at others ropy like oil: in several cases thick, viscid, and always transparent, like jelly; in other circumstances, semiconcrete, and white, yellow, or green, like a purulent humour. None of these changes have yet been chemically examined, and hardly even has the attention which they deserve been bestowed upon them.

MUFTI, or MUPHTI, the chief of the ecclesiastical order, or primate, of the mussulman religion. The authority of the mufti is very great in the Ottoman empire; for even the sultan himself, if he would preserve any appearance of religion, cannot, without hearing his opinion, put any person to death, or so much as inflict any corporal punishment. In all actions, especially criminal ones, his opinion is required by giving him a writing, in which the case is stated under feigned names, which he subscribes with the words, *He shall*, or *shall not, be punished*. Such outward honour is paid to the mufti, that the grand seignior himself rises up to him, and advances seven steps to meet him, when he comes into his presence. The election of the mufti is solely in the grand seignior, who presents him with a vest of rich sables, &c. If he is convicted of treason, or any great crime, he is put into a mortar, kept for that purpose in the Seven Towers at Constantinople, and pounded to death.

MUGGLETONIANS, a religious sect, which arose in England about the year 1657; so denominated from their leader Lodowick Muggleton, a journeyman taylor, who, with his associate Reeves, asserted, that they were the two last witnesses of God that should appear before the end of the world.

MUGIL, *mullet*, a genus of fishes of the order abdominales. The generic character is, lips membranaceous; the inferior carinated within: teeth none; at the corners of the mouth an inflicted callus: gill-membrane with six curved rays: body fleshy; scales large; dorsal fins two.

1. Mugil cephalus, common mullet. This fish, the mugil and mugilis of the ancient Romans, is a very common inhabitant of the Mediterranean and northern seas, frequenting chiefly the shallow parts near the shores, and feeding on the smaller kind of worms, sea-insects, and vegetables. Its general length is from 12 to 15 or 16 inches, and its colour blueish-grey, darker on the back, and silvery on the abdomen; the sides are marked, like those of the grayling, with several dusky stripes, according to the rows of scales, which are large and rounded; the fins are blueish; the first dorsal fin, which is situated on the middle of the back, consists of four very strong rays; the second dorsal fin is placed opposite the anal, and has only soft rays; the base of the dorsal and anal fin, as well as that of the tail, is scaly, and the tail is forked or lunated.

The mullet is found not only in the European seas, but in the Indian and Atlantic oceans. It is observed to assemble frequently in small shoals near the shore, in quest of food, burrowing into the soft mud, and leaving the trace of its head in the form of a round hole.

In the spring and early summer months, this fish, like the salmon, ascends rivers to a considerable distance; and when preparing for these expeditions, is observed in shoals near the surface of the water, at which time the fishermen endeavour to avail themselves of the opportunity of surrounding them with their nets, which the fish are said to show great address in escaping from.

The mullet is considered as an excellent fish for the table, though not a fashionable one in our own country. Dr. Bloch informs us, that it is generally eaten with the addition of oil and lemon-juice. The spawn is often prepared into an inferior kind of caviar, called botargo, by drying and salting it; in which manner also the fish itself, in plentiful seasons, is occasionally preserved. See Plate XCI. Nat. Hist. fig. 272.

2. Mugil crenilabis, crenated mullet. Size of the common mullet; length about twelve inches; colour whitish; scales rather large, and marked by a dusky streak; upper lip gaping, lower bicarinated within, and both lips crenulated on the edges; fins glaucous white, the pectoral marked at the base by a round black spot; tail forked: native of the Red Sea. There are seven other species.

MUG-WORT, in botany. See ARTEMESIA.

MUHLENBERGIA, a genus of the class and order triandria digynia. The calyx is one-leaved, minute, lateral; corolla two-valved. There is one species, a grass of America.

MUID, a large measure in use among the French, for things dry. The muid is no real vessel used as a measure, but an estimation of several other measures, as the septier, mine, minot, bushel, &c.

MUID is also one of the nine casks, or regular vessels, used in France, to put wine and other liquors in. The muid of wine is divided into two demi-muids, four quarter-muids, and eight half-quarter muids, containing 36 septiers.

MULBERRY. See MORUS.

MULE, in zoology, a mongrel kind of quadruped, usually generated between an ass and a mare, and sometimes between a horse and a she-ass; but the signification of the word is commonly extended to every kind of animal produced by a mixture of two different species. There are two kinds of these animals: one from the he-ass and mare, the other from the horse and the she-ass. We call them indifferently mules, but the Romans distinguished them by proper appellations. The first kind are the best and most esteemed, as being larger, stronger, and having least of the ass in their disposition. The largest and stoutest asses, and the fairest and finest mares, are chosen in those countries where these creatures are most in use; as in Spain, Italy, and Flanders. In the last especially, they succeed in having very stately mules from the size of their mares, some of them 16 and some 17 hands high, which are very serviceable as sumpter-mules, in the army. But since the Low-countries are no longer under the dominion of Spain, they breed fewer mules. These creatures are very much commended for their being stronger, surer-footed, going easier, being more cheaply maintained, and lasting longer, than horses. They are commonly of a black brown, or quite black, with that shining list along the back and across the shoulders which distinguishes asses. In former times they were much more common in this country than at present, being often brought over in the days of popery by the Italian princes. They continued longest in the service of millers, and are yet in use among them in some places, on account of the great loads they carry on their

back. As they are capable of being trained for riding, bearing burdens, and for draught, there is no doubt that they might be usefully employed in many different services. But they are commonly found to be vicious, stubborn, and obstinate to a proverb; which whether it occasions or is produced by the ill usage they meet with, is a point not easily settled. Whatever may be the case of asses, it is allowed that mules are larger, fairer, and more serviceable, in mild than in warm climates. In the British American colonies, both on the continent and in the islands, but especially in the latter, they are much used and esteemed; so that they are frequently sent to them from hence; suffer less in the passage, and die much seldomer, than horses; and commonly yield, when they arrive, no inconsiderable profit.

It has commonly been asserted, that animals produced by the mixture of two heterogeneous species, are incapable of generating, and thus perpetuating the monstrous breed: but this, we are informed by M. Buffon, is now discovered to be a mistake.

MULES, among gardeners, denote a sort of vegetable monsters produced by putting the farina fecundans of one species of plant into the pistil or utricle of another. The carnation and sweet-william being somewhat alike in their parts, particularly their flowers, the farina of the one will impregnate the other, and the seed so enlivened will produce a plant differing from either. An instance of this we first had in Mr. Fairchild's garden at Hoxton, where a plant is seen neither sweet-william nor carnation, but resembling both equally: this was raised from the seed of a carnation that had been impregnated by the farina of the sweet-william. These couplings being not unlike those of the mare with the ass, which produce the mule, the same name is given them; and they are, like the others, incapable of multiplying their species. This furnishes a hint for altering the property and taste of any fruit, by impregnating one tree with the farina of another of the same class, *e. g.* a codlin with a pearmain, which will occasion the codlin so impregnated to last a longer time than usual, and to be of a sharper taste. Or if the winter fruits are fecundated with the dust of the summer kinds, they will ripen before their usual time. And from the accidental coupling of the farina of one with another, it may possibly be, that in an orchard where there is variety of apples, even the fruit gathered from the same tree differ in their flavour, and in the season of maturity. It is also from the same accidental coupling that the numberless varieties of fruits and flowers raised every day from seed proceed.

MULLER, or MULLAR, denotes a stone flat and even at the bottom, but round at top, used for grinding of matters on a marble. The apothecaries use mullers to prepare some of their testaceous powders; and painters for their colours, either dry or in oil.

MULLERIA, a genus of the class and order diadelphia decandria. The pericarp is elongated, fleshy, necklace-form, with one-seeded globules. There is one species, a tree of Surinam.

MULLET, or MOLLET, in heraldry, a bearing in form of a flat, or rather of the rowel of a spur, which it originally represented.

MULLUS, *surmullet*, a genus of fishes of the order thoracici. The generic character is, head compressed, scaly; mouth bearded; gill-membrane three-rayed; body covered with large subdeciduous scales.

1. Mullus ruber, the red surmullet, is principally found in the Mediterranean and northern seas, where it arrives at the length of 12 or 15 inches: its colour is an elegant rose-red, tinged with olive-colour on the back, and of a silvery cast towards the abdomen. The surmullet is a fish of a strong and active nature, swimming briskly, and feeding principally on the smaller fishes, worms, and sea-insects. It is generally considered as a very delicate fish, and is celebrated for having been the fashionable object of Roman luxury, and for which such enormous sums are reported to have been sometimes given; though it is probable that the high estimation in which it was held by the ancient Greeks and Romans was more owing to a prejudice entertained on account of its elegant appearance, than to its real merit as a food. The Romans practised a singular refinement in luxury, by first bringing the fish alive to the table in a glass vessel, in order that the guests might enjoy the pleasure of contemplating the beautiful changes of its evanescent colours during the time of its gradual expiration; after which it was prepared for their repast.

2. Mullus surmuletus, striped surmullet, of similar size and general appearance with the preceding, but marked on each side by two and sometimes three longitudinal yellow stripes: native of the Mediterranean, but found occasionally in the Atlantic and other seas: in equal esteem as a food with the former, of which it has even been considered by some authors as a variety.

3. Mullus Indicus, Indian surmullet. Size and habit of the common or red mullet; colour extremely beautiful in the living fish, but fading very soon after death; upper part of the head and back dark changeable purple, growing faint on the sides, which are marked by a few longitudinal azure and golden lines, and by two oblong spots on each side; the first situated about the middle of the body, smallish, and of an opaline or changeable golden and white colour; the second situated near the tail, larger, and of a dark purple; abdomen white; dorsal fin purple, streaked with light blue; pectoral and anal pink-colour: native of the Indian seas: observed by Dr. Russel near Visgapatam: inferior as a food to the red mullet, and not much esteemed.

4. Mullus barbatus, inhabits the European, Mediterranean, and Pacific seas: body, when deprived of its scales, red. Nothing can be more beautiful than the colours of this fish, when in the act of dying; and nothing more delicious than its flesh. The Romans held it in such repute, that prodigious sums were given for them: they were frequently bought at their weight in pure silver. See Plate XCI. Nat. Hist. fig. 273. There are two other species.

MULTILATERAL, in geometry, is applied to those figures which have more than four sides or angles, more usually called polygons.

MULTINOMIAL, or MULTINOMIAL ROOTS, in mathematics, such roots as are composed of many names, parts, or members; as, $a + b + d + c$, &c. See ROOT.

MULTIPLE, in arithmetic, a number which comprehends some other several times, thus 6 is a multiple of 2.

Multiple ratio, or proportion, is that which is between multiples. If the less term of the ratio is an aliquot part of the greater the ratio of the greater to the less is called multiple, and that of the less to the greater submultiple. A submultiple number is that contained in the multiple; thus, the numbers 1, 2, and 3, are submultiples of 9. Duple, triple, &c. ratios, as also subduples, subtriples, &c. are so many species of multiple and submultiple ratios. See Ratio.

MULTIPLICAND. See Arithmetic.

MULTIPLICATION. See Arithmetic, and Algebra.

MULTIPLYING GLASS. See Optics.

MUM, a kind of malt liquor, much drunk in Germany, and chiefly brought from Brunswick, which is the place of most note for making it.

MUMMY. See Embalming.

MUNCHAUSIA, a genus of the class and order polyadelphia polyandria. The calyx is six-cleft; petals clawed; stamina in six bodies; pistils superior. There is one species, a tree of Java.

MUNICIPAL, in the Roman civil law, an epithet which signifies invested with the rights and privileges of Roman citizens. Thus the municipal cities were those whose inhabitants were capable of enjoying civil offices in the city of Rome.

Municipal, among us, is applied to the laws that obtain in any particular city or province: and those are called municipal officers who are elected to defend the interest of cities, to maintain their rights and privileges, and to preserve order and harmony among the citizens; such as mayors, sheriffs, &c.

MUNTINGIA, a genus of the class and order polyandria monogynia. The calyx is five-parted; corolla five-petalled; berry five-celled: seeds many. There is one species, a shrub of Jamaica.

MURÆNA, a genus of fishes of the order apodal. The generic character is, body eel-shaped; pectoral fins none; spiracle on each side the neck.

1. Muræna Helena, Roman muræna. This fish the celebrated favourite of the ancient Romans, who considered it as one of the most luxurious articles of the table, is found in considerable plenty about several of the Mediterranean coasts, where it arrives at a size at least equal if not superior, to that of an eel. Its colour is a dusky greenish-brown, pretty thickly variegated on all parts with dull yellow subangular marks or patches, which are disposed in a somewhat different manner in different individuals, and are generally scattered over with smaller specklings of brown, the whole forming a kind of obscurely reticular pattern. The muræna is capable of living with equal facility both in fresh and salt water, though principally found at sea. In its manners it much resembles the eel and the conger, being extremely voracious, and preying on a variety of smaller animals. The ancients, who kept it in reservoirs appropriated for the purpose, are said to have sometimes tamed it to such a degree as to come at the signal of its master in order to receive its food. Pliny records a most disgusting and barbarous instance of tyranny practised by one Vedius Pollio, who was in the habit of causing his offending slaves to be thrown into the reservoirs in which he kept his murænæ; expressing a savage delight in thus being able to taste in an improved state their altered remains. The emperor Augustus, according to Seneca, honoured this man with his presence at one of his entertainments; when a slave happening to break a valuable crystal vase, was immediately ordered to be thrown to the murænæ; but the poor boy flying to the feet of Augustus, requested rather to die any death than thus to be made the food of fishes. The emperor being informed of this extraordinary mode of punishment, immediately ordered all the chrystal vessels in the house to be broken before his face, and the ponds of the barbarous owner to be completely filled up; at the same time giving the slave his freedom, but sparing the life of the offender in consideration of former friendship. See Plate XCI. Nat. Hist. fig. 276.

2. Muræna ophis, spotted muræna. Observed by Forskal; native of the Red Sea; has a rising callus between the eyes, gold-coloured irides, upper lip shorter than the lower, and the dorsal and anal fins united at the tail. See Plate XCI. Nat. Hist. fig. 275.

3. Muræna catenata, chain-striped muræna. This species, of which the individuals hitherto described appear to be of the size of a smallish eel, is of a brown colour, crossed by large chain-like white bands, somewhat irregular in their form on different parts of the animal, and marked by numerous brown spots and freckles. This fish is a native of Surinam.

4. Muræna reticulata, reticulated muræna. In size and general form, this resembles the preceding species, but differs in colours and in the disposition of the dorsal fin, which commences immediately at the back of the head, and is continued round the tail, where it unites with the vent-fin. Native of the Indian seas.

5. Muræna conger, conger eel; inhabits the European seas and rivers; is extremely voracious, feeding on other fish, crabs in their soft state, and particularly carcases. It grows to a vast size. See Plate XCI. Nat. Hist. fig. 274. There are four other species.

MURDER, or Murther. See Homicide.

MUREX, in natural history, a genus of univalve or simple shells, without any hinge, formed of a single piece, and beset with tubercles or spines. The mouth is large and oblong, and has an expanded lip, and the clavicle is rough.

The clavicle of the murex is in some species elevated, in others depressed; and the mouth is sometimes dentated, and at others smooth; the lip also in some is digitated, in others elated, and in some laciniated; and the columella is in some smooth, in others rugose.

Murex, in zoology, a genus of insects belonging to the order of vermes testacea. This animal is of the snail kind: the shell consists of one spiral valve, rough, with membranaceous furrows; and the aperture terminates in an entire canal, either staight, or somewhat ascending. There are 60 species, particularly distinguished by peculiarities in their shells, &c. See Plate XCI. Nat. Hist. figs. 277, 278.

In the accounts of a Spanish philosopher it is mentioned, that on the coasts of Guayaquil and Guatimala in Peru, the murex is also found. The shell which contains it adheres to the rocks that are washed by the sea. It is of the size of a large walnut. The liquor may be extracted two ways: some kill the animal after they have drawn

it out of the shell, then press it with a knife from head to tail, separate from the body the part where the liquor is collected, and throw away the rest. When this operation, after being repeated on several snails, has afforded a certain quantity of fluid, the thread intended to be dyed is dipped in it, and the process is finished. The colour, which is at first of the whiteness of milk, becomes afterwards green, and is not purple till the thread is dry. Those who disapprove of this method draw the fish partly out of the shell, and, squeezing it, make it yield a fluid which serves for dyeing: they repeat this operation several times at different intervals, but always with less success. If they continue it, the fish dies. No colour at present known, says the Abbe Raynal, can be compared to this, either as to lustre, liveliness, or duration. It succeeds better on cotton than wool, linen, or silk.

MURIAT, *green sand of Peru*. This ore, which was brought from Peru by Dombey, is a grass-green powder, mixed with grains of quartz. When thrown on burning coals, it communicates a green colour to the flame. It is soluble both in nitric and muriatic acids without effervescence. The solution is green. This mineral was first proved to contain muriatic acid by Berthollet. Afterwards Proust analyzed it. But Vauquelin announced that he considered it merely as an oxide of copper mixed with common salt. However, a subsequent examination convinced him that his opinion was unfounded; and that the mineral was really a carbonat, as had been affirmed by Berthollet and Proust. This conclusion has been confirmed by Klaproth, who found the green sand of Peru composed of

73.0 oxide of copper
10.1 muriatic acid
16.9 water.

———

100.0

MURIATIC ACID. This substance may be procured by the following process: Let a small pneumatic trough be procured, hollowed out of a single block of wood, about 14 inches long, seven broad, and six deep. After it has been hollowed out to the depth of an inch, leave three inches by way of shelf on one side, and cut out the rest to the proper depth, giving the inside of the bottom a circular form. Two inches from each end cut a slit in the shelf to the depth of an inch, and broad enough to admit the end of small glass tubes, or the points of small retorts. This trough is to be filled with mercury to the height of one quarter of an inch above the surface of the shelf. Small glass jars are to be procured of considerable thickness and strength, and suitable to the size of the trough. One of them, being filled with mercury by plunging it into the trough, is to be placed on the shelf over one of the slits, it ought to be supported in its position; and the most convenient method of doing that is to have a brass cylinder two inches high screwed into the edge of the trough, just opposite to the border of the shelf. On the top of it are fixed two flat pieces of brass, terminating each in a semicircle, moveable freely upon the brass cylinder, and forming together a brass arm terminating in a circle, the centre of which is just above the middle of the slit in the shelf, when turned so as to be parallel to the edge of the shelf. This circle is made to embrace the jar; being formed of two distinct pieces, its size may be increased or diminished at pleasure; and by means of a brass slider it is made to catch the jar firmly.

The apparatus being thus disposed, two or three ounces of common salt are to be put into a small retort, and an equal quantity of sulphuric acid added; the beak of the retort plunged below the surface of the mercury in the trough, and the heat of a lamp applied to the salt in its bosom. A violent effervescence takes place; and air-bubbles rush in great numbers from its beak, and rise to the surface of the mercury in a visible white smoke, which has a peculiar odour. After allowing a number of them to escape, till it is supposed that the common air which previously existed in the retort has been displaced, plunge its beak into the slit in the shelf over which the glass jar has been placed. The air-bubbles soon displace the mercury and fill the jar. The gas thus obtained is called muriatic acid gas.

This substance, in a state of solution in water, was known even to the alchemists; but in a gaseous state it was first examined by Dr. Priestley, in an early part of that illustrious career in which he added so much to our knowledge of gaseous bodies.

1. Muriatic acid gas in an invisible elastic fluid, resembling common air in its mechanical properties. Its specific gravity, according to the experiments of Mr. Kirwan, is 0.002315, or nearly double that of common air. Its smell is pungent and peculiar; and whenever it comes in contact with common air, it forms with it a visible white smoke. If a bottle of it is drawn into the mouth, it is found to taste excessively acid; much more so than vinegar.

2. Animals are incapable of breathing it, and when plunged into jars filled with it, they die instantaneously in convulsions. Neither will any combustible burn in it. It is remarkable, however, that it has a considerable effect upon the flame of combustible bodies; for if a burning taper is plunged into it, the flame, just before it goes out, may be observed to assume a green colour, and the same tinge appears next time the taper is lighted.

3. If a little water is let up into a jar filled with this gas, the whole gas disappears in an instant, the mercury ascends, fills the jar, and pushes the water to the very top. The reason of this is, that there exists a strong affinity between muriatic acid gas and water; and whenever they come in contact, they combine and form a liquid, or, which is the same thing, the water absorbs the gas. Hence the necessity of making experiments with this gas over mercury. In the water cistern not a particle of gas would be procured. Nay, the water of the trough would rush into the retort and fill it completely. It is this affinity between muriatic acid gas and water which occasions the white smoke that appears when the gas is mixed with common air. It absorbs the vapour of water which always exists in common air. The solution of muriatic acid gas in water is usually denominated simply muriatic acid by chemists.

4. If a little of the blue-coloured liquid which is obtained by boiling red cabbage-leaves and water, is let up into a jar filled with muriatic acid gas, the usual absorption of the gas takes place, but the liquid at the same time assumes a fine red colour. This change is considered by chemists as a characteristic property of acids.

5. Muriatic acid gas is capable of combining with oxygen. To obtain the combination, we have only to put a quantity of the black oxide of manganese in powder into a retort, and pour over it liquid muriatic acid. Heat is then to be applied to the mixture, and the beak of the retort plunged under water. An effervescence takes place, and a green-coloured gas comes out at the beak of the retort, which may be received in the usual manner in jars. This gas has been ascertained to be a compound of muriatic acid and oxygen. It is called oxy-muriatic acid, and will come under our consideration hereafter.

6. It does not appear from any experiments that have been hitherto made, that any of the simple combustibles are capable of combining with muriatic acid gas. Dr. Priestley found, that sulphur absorbed slowly about the fifth part of it. What remained was inflammable air, burning with a blue flame, and not absorbed by water. He found that phosphorus scarcely absorbed any sensible quantity of it, and that charcoal absorbed it very fast. Hydrogen gas does not produce any sensible change in it. Neither does it seem capable of being affected by azotic gas.

Muriatic acid is capable of combining with two doses of oxygen only. With the first dose, it forms oxymuriatic acid; with the second, hyperoxymuriatic acid. The first of them ought, in strict propriety, to be termed an oxide rather than an acid.

MURIATS. The muriats are a genus of salts which have been long known, and from which indeed the whole of the class have borrowed their name; for to them belongs common salt, the most important and the most indispensably necessary of all the salts. They may be distinguished by the following properties:

When heated, they melt, and are volatilized, at least in part, without undergoing decomposition. The first portions which fly off contain an excess of acid.

Not in the least altered by combustibles, even when assisted by heat.

Soluble in water. For the most part they raise the boiling-point of water.

Effervesce with sulphuric acid, and white acrid fumes of muriatic acid are disengaged.

When mixed with nitric acid, they exhale the odour of oxymuriatic acid.

MURRAIN, or GARGLE, a contagious disease among cattle, principally caused by a hot dry season, or rather by a general putrefaction of the air, which begets an inflammation of the blood, and a swelling in the throat, that soon proves mortal, and is communicated from one to another, though it generally goes no farther than to those of the same kind.

The symptoms of this disease are, a hanging down and swelling of the head, abundance of gum in the eyes, rattling in the throat, a short breath, palpitation of the heart, staggering, hot breath, and a shining tongue.

MURRAYA, a genus of the class and order decandria monogynia. The calyx is five-parted; corolla bell-shaped, with a nectarium encircling the germ; berry one-seeded. There is one species, a tree of the East Indies.

MUS, *the rat*, a genus of quadrupeds of the order glires. The generic character is, upper front-teeth wedge-shaped; grinders on each side three, sometimes only two; clavicles or collar-bones in the skeleton.

This numerous tribe constitutes a formidable phalanx against which mankind find it necessary to employ the various artifices of extirpation, in order to lessen the ravages occasionally suffered by its depredations. In our own island, the black and brown rats, the field and domestic mice, are the principal destroyers; but in other parts of Europe, as well as the hotter regions of Asia, Africa, and America, many other species, still more noxious and formidable, are found. The different kinds vary considerably in their manner of life, some confining themselves entirely to vegetable food, while others are polyphagous, destroying with indiscriminate avidity almost any animal or vegetable substance to which they can gain access. Their pace is, in general, rather quick, and their most usual residence is in obscure subterraneous retreats, from which they principally emerge by night. They are of a prolific nature, and the females are furnished with numerous teats. Some species are migratory; others local or attached to the same residence. Lastly, some are of an uncouth form and disagreeable appearance, while others are remarkable for the elegance of their colours. In the 12th edition of the Systema Naturæ, Linnæus included in this genus the jerboas, the cavys, and several other animals which are now formed into distinct genera. This mode of distribution might perhaps be carried still farther, the habit or appearance of some species differing very considerably from that of the major part of the tribe.

1. Mus zibethicus, musk rat. In the Memoirs of the French Academy of Sciences for the year 1725, there is a complete and excellent description of this animal by M. Sarrazin, at that time king's physician at Quebec. It is from the above description that the count de Buffon has drawn up the major part of his own account, and indeed it does not appear possible to add any thing material to what Mons. Sarrazin has delivered. This animal is of the size of a small rabbit, and is extremely common in Canada. Its head is short, like that of a water-rat; the eyes large; the ears very short, rounded, and covered internally as well as externally with hair. It has, like the rest of this tribe, four very strong cutting teeth, of which those in the lower jaw are near an inch long; those in the upper somewhat shorter: the fur on the whole body is soft and glossy, and beneath is a fine fur, or thick down, as in the beaver; the toes on all the feet are simple, or without membranes, and are covered with hair; the tail is nearly as long as the body, and is of the same form with that of the sorex moschatus or musk shrew, being laterally compressed; it is nearly naked, and covered with small scales intermixed with scattered hairs. The general colour of the animal is a reddish brown; of the tail ash-colour. In its general appearance this animal greatly resembles the beaver, except in size, and in the form of its tail. It has also similar instincts and dispositions; living in a social state in the winter, in curiously-constructed huts or cabins, built near the edge of some lake or river. These huts are about two feet and a half or three feet in diameter, plaistered with great neatness in the inside, and covered externally with a kind of basket-work, of rushes, &c. interlaced together so as to form a compact and secure guard impermeable by water. During the winter these receptacles are generally covered by several feet of snow, and the animals reside in them without being in-

commoded by it, several families commonly inhabiting each cabin. It is added that the insides of the receptacles are furnished with a series of steps, to prevent them from being injured by inundations. These animals do not lay up a stock of provisions like the beaver, but form subterraneous passages beneath and round their cabins, to give themselves an opportunity of procuring occasional supplies of roots, herbage, &c. According to Mons. Sarrazin the animal is particularly calculated by nature for its subterraneous habits, having a great muscular force in its skin, which enables it to contract its body occasionally into a small volume: it has also a great suppleness in the false ribs, which easily admit of contraction, so that it is enabled to pass through holes impervious to much smaller animals than itself.

During the summer these creatures wander about in pairs, feeding voraciously on herbs and roots. Their odour, which resembles that of musk, is so strong as to be perceived at a considerable distance; and the skin, when taken from the body, still retains the scent: this musky odour is owing to a whitish fluid deposited in certain glands situated near the origin of the tail. It has been supposed that the calamus aromaticus, or sweet flag (acorus calamus, Lin.), which these animals select as a favourite food, may contribute to their fragrant smell. They walk and run in an awkward manner, like the beaver, and they cannot swim so readily as that animal, their feet being unfurnished with webs. Their voice is said to resemble a groan. The females produce their young towards the beginning of summer, and have five or six at a time; and these, if taken early, are easily tamed, and become very sportive; and it is remarkable that the tail, which in the full-grown animal is as long as the body, is at that period very short.

The fur of this species is greatly esteemed as a commercial article, resembling that of the beaver. Linnæus, in the twelfth edition of the Systema Naturæ, ranked the animal under the genus castor; and Mr. Pennant has followed his example. Mr. Schreber, however, considers it as belonging in strict propriety to the present genus. See Plate XCII. Nat. Hist. fig. 279.

2. Mus decumanus, Norway rat. This domestic species, which is now become the common rat of our own island, and is popularly known by the name of the Norway rat, is supposed to be a native of India and Persia, from which countries it has been imported into Europe. In England it seems to have made a national conquest over the black rat, which is now become rare in comparison. The brown rat is larger than the black rat, measuring nine inches from the nose to the tail, which is of the same length, and marked into about 200 rings or circular spaces; the colour of the animal is a pale tawney-grey, whitish beneath; the fore feet have four toes, with a claw in place of a fifth. It is a bold and voracious animal, and commits great havoc in granaries, &c. Sometimes it takes up its residence in the banks of waters, and swims occasionally with almost as much facility as the water rat, or mus amphibius. In its general manner of life it agrees with the black rat; and not only devours grain and fruits, but preys on poultry, rabbits, and various other animals. It is a very prolific species, and produces from ten to twelve or fourteen, or even sometimes eighteen, young at a time. When closely pursued, it will sometimes turn upon its adversary, and bite with great severity. It seems to have made its first appearance in England about eighty years ago, and is still much less frequent in France and some other parts of the continent than the black rat.

3. Mus rattus, black rat. This species, like the former, though now so common in most parts of Europe, is supposed to have been originally introduced from India and Persia. Its general length from nose to tail is seven inches, and of the tail eight inches; the colour of the head and whole upper part of the body is a dark iron or blackish grey; the belly is of a dull ash-colour; the legs are dusky, and very slightly covered with hair; the fore feet, as in the brown rat, have only four toes, with a small claw in place of a fifth; the tail is nearly naked, coated with a scaly skin, and marked into numerous divisions or rings. Like the former species, this animal breeds frequently, and commonly brings about six or seven young at a time. Sometimes they increase so fast as to overstock the place of their abode, in which case they fight and devour each other. It is said that this is the reason why these animals, after being extremely troublesome, sometimes disappear suddenly. Various are the methods made use of for the expulsion of rats from the places they frequent; among which none is more singular than that mentioned by Gesner, who tells us he had been informed that if a rat is caught and a bell tied round its neck, and then set at liberty, it will drive away the rest wherever it goes. This expedient appears to be occasionally practised in modern times with success. A gentleman travelling through Mecklenburgh, about 30 years ago, was witness to the following curious circumstance in the post-house in New Stargard. After dinner the landlord placed on the floor a large dish of soup, and gave a loud whistle. Immediately there came into the room a mastiff, a fine Angora cat, an old raven, and a remarkably large rat, with a bell about its neck. The four animals went to the dish, and without disturbing each other, fed together; after which the dog, cat, and rat, lay before the fire, while the raven hopped about the room. The landlord, after accounting for the familiarity which existed among the animals, informed his guest that the rat was the most useful of the four, for the noise he made had completely freed the house from the rats and mice with which it was before infested.

4. Mus musculus, common mouse. The manners and appearance of this little animal are so universally known, that it seems almost unnecessary to particularise it by a formal description. It is a general inhabitant of almost every part of the Old Continent, but it is doubtful whether it is originally a native of America, though now sufficiently common in many parts of the New World, as well as in many of its scattered islands.

The mouse, though wild and extremely timid, is not of a ferocious disposition, but may be easily tamed, and soon after it has been taken, will begin to feed without fear, in the immediate presence of its captors. The white variety is frequently kept in a tame state, and receives an additional beauty from the bright red colour of its eyes; a particularity which generally accompanies the white varieties, not only of this tribe, but of many other quadrupeds.

The mouse is a prolific animal: the experiment of

Aristotle is well known, and often quoted. He placed a pregnant mouse in a vessel of grain, and after a short space found in it no less than the number of 120, all which he concluded, were the descendants of the mouse he had inclosed.

The fur of the mouse is remarkably soft and elegant, and the structure of the hair in this animal, as well as in the rat, and probably in many others of this genus, is singularly curious; each hair, when microscopically examined, appearing internally divided into a kind of transverse partitions, as if by the continuation of a spiral fibre; a structure very different from that of the hair of most other animals, and of which the particular nature seems not very distinctly understood.

Derham, in his Physico-Theology, conceives that this mechanism of a spiral fibre may serve for the "gentle evacuation of some humour out of the body;" and adds, that "perhaps the hair serves as well for the insensible perspiration of hairy animals as to fence against cold and wet." Whatever is the real nature or use of the above structure, its appearance cannot fail to excite astonishment in those who take the pains of examining it with a good microscope, by which they will obtain a clear idea of this curious appearance.

In Aldrovandus, who relates the circumstance from Gesner, we meet with a direction for changing, as it were, a mouse into a cat, by making it the incessant persecutor and enemy of the rest of its species. This is to be effected by placing several mice together in a vessel without food, when, after a certain space, they will be so stimulated by hunger as to destroy each other: the surviving animal being then liberated, will, according to this author, become the most destructive enemy of his own tribe, and will kill every one he meets. Another singular and most cruel experiment is quoted by Aldrovandus from Mizaldus, who tells us, that if two or three mice are shut up in an earthen pot, and placed over a fire, the shrill cries which they utter will attract the mice in the other part of the house, and cause them to precipitate themselves into the fire. Whatever truth there may be in this experiment, it is certain that, on the shrill cry of distress uttered by one of these animals kept with several others in a cage, the rest will frequently attack and destroy it.

5. Mus sylvaticus, wood mouse. This animal chiefly frequents dry and elevated grounds, and is found in woods and fields in great plenty. It appears to be common in all the temperate parts of Europe, and even in Russia. It sometimes varies in size, individuals being occasionally met with which exceed the rest in magnitude, though different in no other respect. Its general length is about four inches and a half from nose to tail, and the tail, which is slightly covered with hair, measures four inches. The colour of the animal is a yellowish brown above and whitish beneath, the colours being pretty distinctly marked or separated; the eyes are full and black, and the snout rather blunt. These animals retire into holes among brush-wood, and under the trunks of trees, where they amass great quantities of acorns, nuts, and beech-mast. According to Buffon, a whole bushel has sometimes been found in a single hole. These holes are about a foot or more under ground, and are often divided into two apartments; the one for living in along with their young, the other for a magazine of provisions. Considerable damage is often done to plantations by these animals, which carry off new-sown acorns, &c. The count de Buffon affirms, that in France more mischief is done by these creatures than by all the birds and other animals put together; and adds, that the only way to prevent this is by laying traps, at ten paces asunder, through the whole extent of the sown ground. No other apparatus, he says, is necessary than a roasted walnut, placed under a stone supported by a stick: the animals come to eat the walnut, which they prefer to acorns; and as the walnut is fixed to the stick, whenever they touch it, the stone falls and kills them. The same expedient may be as successfully used for the destruction of the short-tailed field mouse, which likewise commits great havoc in fields and plantations. When the count de Buffon first practised this experiment, he desired that all the field mice thus taken in traps might be brought to him, and found with astonishment, that above 100 were taken each day from a piece of ground consisting only of about 40 of our acres. From the 15th of November to the 8th of December, above 2000 were destroyed in this manner. When the frost becomes severe, they retire into their holes, and feed on the stores they have collected. They abound, like many other animals of this genus, chiefly in autumn, and are far less common in the spring; for if provisions happen to fail them in the winter, it is thought that they destroy each other; a circumstance which is known occasionally to take place in many other species.

The long-tailed field mouse is a very prolific animal, breeding more than once a year, and often producing litters of ten at a time. In one of their holes have been found two females, with 20 young. Specimens have sometimes been seen perfectly white, with red eyes.

6. Mus messorius, harvest mouse. This small species seems to have escaped the notice of British naturalists till it was observed by the late Mr. Gilbert White, of Selburne in Hampshire, in which county it is frequent. Mr. White, in the year 1767, communicated the animal to Mr. Pennant, who introduced it into the British Zoology.

"These mice," says Mr. White, "are much smaller and more slender than the mus domesticus medius of Ray, and have more of the squirrel or dormouse colour; their belly is white; a straight line along their sides divides the shades of their back and belly. They never enter into houses, are carried into ricks and barns with the sheaves, abound in harvest, and build their nest amidst the straws of corn above ground, and sometimes in thistles. They breed as many as eight at a litter, in a little round nest composed of the blades of grass or wheat. One of these nests was procured in the autumn of 1767, most artificially platted, and composed of the blades of wheat, perfectly round, and about the size of a cricket-ball, with the aperture so ingeniously closed, that there was no discovering to what part it belonged. It was so compact and well filled, that it would roll across the table without being discomposed, though it contained eight little mice that were naked and blind. As this nest was perfectly full, how could the dam come at her litter respectively, so as to administer a teat to each? Perhaps she opens different places for that purpose, adjusting them again

when the business is over; but she could not possibly be contained herself in the ball with her young, which moreover would be daily increasing in bulk. This wonderful procreant cradle, an elegant instance of the effect of instinct, was found in a wheat-field, suspended in the head of a thistle."

Mr. White adds, that "though these animals hang their nests for breeding up amidst the straws of standing corn, above ground, yet in the winter they burrow deep in the earth, and make warm beds of grass; but their grand rendezvous seems to be in corn-ricks, into which they are carried in harvest." A neighbour of Mr. White's housed an oat-rick, in which were some hundreds assembled under the thatch. The measure of the animal is just two inches and a quarter from nose to tail, and the tail is just two inches long. Two of them in a scale just weighed down a copper halfpenny, which was about the third of an ounce avoirdupois: so that they may be considered as the smallest of the British quadrupeds.

7. Mus minutus, minute mouse. This species, according to Dr. Pallas, is frequent in the birch-woods of Siberia, as well as in many of the temperate parts of Russia, frequenting corn-fields and barns. Its general colour is a deep tawny above and white below; the nose is sharpish and of a dusky colour, with a whiteness at the corners of the mouth; the ears are hid in the fur; the feet grey; the length from nose to tail is little more than two inches, and the weight not half a dram. Those found in Siberia are of a richer or more fulvous colour than those of other regions. This animal, Dr. Pallas says, is very frequent in autumn and winter in corn-ricks and about granaries, and is often found intermixed with the mus agrarius, inhabiting similar places. It seems extremely nearly allied to the harvest mouse, and it is not impossible that it may in reality be the same animal, the differences appearing almost too slight for a specific distinction.

8. Mus amphibius, water rat. The water rat is a general inhabitant of the temperate, and even the colder, parts of Europe and Asia, and occurs also in North America, frequenting rivers and stagnant waters, and forming its burrows in the banks. It is of a thicker and shorter form than many others of this genus, and has somewhat of the shape of a beaver. Mr. Ray, following an error of Willughby, describes it as having the fore-feet webbed; and Linnæus, in his Systema Naturæ, characterizes it from that very circumstance, but acknowledges that he had not himself examined the animal. In reality, however, there is no such appearance in the feet of the water rat, and the notion seems to have been hastily adopted from observing the facility with which it swims and dives. The general length of the water rat is about seven inches, and the tail about five. Its colour is blackish-ferruginous above, and deep cinereous beneath; the nose is thick and blunt, the eyes small, the ears rounded and hid in the fur. In colour it appears to vary in different regions, being sometimes nearly black, and sometimes paler than usual. It also varies as to size, and the varieties have been mistakenly considered as distinct species. This animal never frequents houses, but confines itself to the banks of waters, and is supposed to live on fish, frogs, &c. and probably on various roots and other vegetable substances. Dr. Pallas, however, is unwilling to admit that it preys at all upon fish, though reported so to do by the count de Buffon and others. At some seasons of the year it is observed to have a musky scent. The female produces her young in April, and generally brings about five or six at a time. The measures of this species, as given by Mr. Schreber, are as follow, viz. from nose to tail six inches and a half, and of the tail three inches.

9. Mus lemmus, lemming rat. The wonderful migrations of this species have long rendered it celebrated in the annals of natural history. It is remarkable, however, that no accurate figure of it was published till Dr. Pallas caused it to be engraved in his excellent work on the Glires.

The first describer of the lemming seems to have been Olaus Magnus, from whom several of the older naturalists have copied their accounts. Afterwards Wormius gave a more particular description; since which, Ricaut, in the Philosophical Transactions, Linnæus, in the Acta Holmiensia, and Dr. Pallas, in his publication before mentioned, have still farther elucidated its history and manners. See Plate XCII. Nat. Hist. fig. 280.

The lemming differs in size and colour according to the regions it inhabits: those which are found in Norway being almost as large as a water rat, while those of Lapland and Siberia are scarce larger than a field mouse; the Norwegian measuring more than five inches from nose to tail, while those of Lapland and Siberia scarce exceed three. The colour of the Norway kind is an elegant variegation of black and tawny on the upper parts, disposed in patches and clouded markings; the sides of the head and the under parts of the body being white, the legs and tail greyish. In the Lapland kind the colour is chiefly a tawny brown above, with some indistinct dusky variegations, and beneath of a dull white: the claws are also smaller than in the Norwegian animal. The head of the lemming is large, short, thick, and well furred; the snout very obtuse; the ears very small, rounded, and hid in the fur; the eyes small; the neck short and broad; the body thick; and the limbs short and stout, especially the fore legs; the fore-feet are broad, furnished with five toes, which have strong, compressed, and somewhat crooked claws, of which the three middle ones are longer than the rest; on the hind-feet are also five toes, with smaller claws than those of the fore-feet; the tail is very short, thick, cylindric, obtuse, and covered with strong hairs, disposed like those of a pencil at the tip.

The natural or general residence of the lemming is in the Alpine or mountainous parts of Lapland and Norway, from which tracts, at particular but uncertain periods, it descends into the plains below in immense troops, and by its incredible numbers becomes a temporary scourge to the country, devouring the grain and herbage, and committing devastations equal to those caused by an army of locusts. These migrations of the lemming seldom happen oftener than once in ten years, and in some districts still less frequently, and are supposed to arise from an unusual multiplication of the animals in the mountainous parts they inhabit, together with a defect of food; and, perhaps, a kind of instinctive prescience of unfavourable seasons, for it is observable that their chief migrations are made in the autumn of such years as are followed by a very severe winter. The

inclination or instinctive faculty which induces them, with one consent, to assemble from a whole region, collect themselves into an army, and descend from the mountains into the neighbouring plains, in the form of a firm phalanx, moving on in a straight line, resolutely surmounting every obstacle, and undismayed by every danger, cannot be contemplated without astonishment. All who have written on the subject agree that they proceed in a direct course, so that the ground along which they have passed appears at a distance as if it had been ploughed; the grass being devoured to the very roots, in numerous stripes, or parallel paths, of one or two spans broad, and at the distance of some ells from each other. This army of mice moves chiefly by night, or early in the morning, devouring the herbage as it passes, in such a manner that the surface appears as if burnt. No obstacles which they happen to meet in their way have any effect in altering their route; neither fires, nor deep ravines, nor torrents, nor marshes or lakes: they proceed obstinately in a straight line; and hence it happens that many thousands perish in the waters, and are found dead by the shores. If a rick of hay or corn occurs in their passage, they eat through it; but if rocks intervene which they cannot pass, they go round, and then resume their former straight direction. If disturbed or pursued while swimming over a lake, and their phalanx separated by oars or poles, they will not recede, but keep swimming directly on, and soon get into regular order again; and have even been sometimes known to endeavour to board or pass over a vessel. On their passage over land, if attacked by men, they will raise themselves up, uttering a kind of barking sound, and fly at the legs of their invaders, and will fasten so fiercely at the end of a stick, as to suffer themselves to be swung about before they will quit their hold; and are with great difficulty put to flight. It is said that an intestine war sometimes takes place in these armies during their migrations, and that the animals thus destroy each other.

The major part, however, of these hosts, is destroyed by various enemies, and particularly by owls, hawks, and weazels, exclusive of the numbers which perish in the waters; so that but a small number survive to return, which they are sometimes observed to do, to their native mountains.

In their general manner of life they are not observed to be of a social disposition, but to reside in a kind of scattered manner, in holes beneath the surface, without laying up any regular provision, like some other animals of this tribe. They are supposed to breed several times in a year, and to produce five or six at once. It has been observed that the females have sometimes brought forth during their migrations, and have been seen carrying some in their mouths, and others on their backs. In some parts of Lapland they are eaten, and are said to resemble squirrels in taste.

It was once believed that these animals fell from the clouds at particular seasons, and some have affirmed that they have seen a lemming in its descent; but an accident of this kind is easily accounted for, on the supposition of a lemming escaping now and then from the claws of some bird which had seized it, and thus falling to the ground; a circumstance which is said not unfrequently to take place when the animals are seized by crows, gulls, &c.

10. Mus œconomicus, œconomic rat. The œconomic rat, so named from its provident disposition, and the skill with which it collects its provisions, is a native of Siberia, inhabiting that country in vast abundance, and even extending as far as Kamtschatka. Its curious history has been given with great exactness by Dr. Pallas: who informs us that these little animals make their burrows with wonderful skill, immediately below the surface, in soft turfy soils; forming a chamber, of a flattish arched form, of a small height, and about a foot in diameter, to which they sometimes add as many as thirty small pipes or entrances, and near the chamber they frequently form other caverns, in which they deposit their winter stores; these are said to consist of various kinds of plants, even of some species which are poisonous to mankind. They gather them in summer, harvest them with great care, and even sometimes bring them out of their cells in order to give them a more thorough drying in the sun. The chief labour rests on the females; the males during the summer wandering about in a solitary state, inhabiting some old nests occasionally, and living during that period on berries, without touching the hoards, which are reserved for winter, when the male and female reside together in the same nest. They are said to breed several times in the year, the female producing two or three young at a time.

The migrations of this little species are not less extraordinary than those of the lemming, and take place at uncertain periods. Dr. Pallas imagines that the migrations of those inhabiting Kamtschatka may arise from some sensations of internal fire in that volcanic country, or from a prescience of some unusual and bad season. Whatever is the cause, the fact is certain. At such periods they gather together, during the spring season, in surprising numbers, except the few that reside about villages, where they can pick up some subsistence; and this makes it probable that their migrations, like those of the lemming, are rather owing to want of food. The mighty host proceeds in a direct course westward, occasionally swimming with the utmost intrepidity over rivers, lakes, and even arms of the sea. During these perilous adventures, some are drowned, and others destroyed by water-fowl, fish, &c.: those which escape rest a while to bask, dry their fur, and refresh themselves, and then again set out on their migration. It is said that the inhabitants of Kamtschatka, when they happen to find them in this fatigued situation, treat them with the utmost tenderness, and endeavour by every possible method to refresh and restore them to life and vigour. Indeed none of the smaller animals are so much esteemed by the Kamtschadales as these, since to their labours they owe many a delicious repast, robbing their hoards in autumn, and leaving there some kind of provision in return, accompanied by some ridiculous presents by way of amends for the theft. As soon as the migrating host of these animals has crossed the river Penshim, at the head of the gulph of that name, it turns southward, and reaches the rivers Judoma and Ochot about the middle of July: the space thus traversed appears astonishing, on consulting the map of the country. The flocks during this time are so numerous, that an observer has waited two hours to see them all pass. Their return into Kamtschatka is in October, and is attended with the utmost festivity and welcome on the

part of the natives, who consider their arrival as a sure prognostic of a successful chace and fishery; and they are said equally to lament their migrations, which are usually succeeded by rainy and tempestuous weather.

This curious species is generally of a tawny colour, darker on the back, and lighter or more approaching to an ash-coloured whiteness beneath: its usual length is about four inches and a quarter, and the tail one inch; its limbs are strong; its eyes small, its ears naked, very short and round, and almost hid beneath the fur of the head.

This animal is also supposed to be an inhabitant of Iceland; at least a species which must be greatly allied to it is found in that country, and is said to be particularly plentiful in the wood of Husafels. In that country, where berries are but thinly dispersed, the little animals are obliged to cross rivers to make their distant foraging excursions, and in their return are obliged to repass the stream; their manner of performing which is thus related by Mr. Olaffen, from the accounts of others, communicated to himself:

"The party, consisting of from six to ten, select a flat piece of dried cow-dung, on which they place the berries they have collected in a heap, on the middle; and then, by their united force, drawing it to the water's edge, launch it, and embark, placing themselves round the heap, with their heads joined over it, and their backs to the water; their tales pendant in the stream, and serving the purpose of rudders."

11. Mus socialis, social mouse. The social mouse is a native of the Caspian deserts between the Volga and the Yaik, and the country of Hircania. It lives in low sandy situations, in large societies; the ground in many places being covered with the little hillocks formed by the earth cast out in forming the burrows, which are said to be about a span deep, with eight or more passages. The animals are always observed to live in pairs, or with a family; they are fond of tulip-roots, which form a principal article of their food. They appear chiefly in the spring, when they are very numerous, but are rarely seen in autumn, and are supposed either to migrate in autumn or to conceal themselves among the bushes, &c. and in the winter to shelter themselves in hay-ricks. The head in this species is thick, and the nose blunt; the whiskers white; the ears oval and naked; the limbs short and strong, and the tail slender. The upper parts are of a light grey, and the under white.

12. Mus cricetus, hamster rat. Of the pouched rats the hamster is the most remarkable, and indeed is the only European species provided with those peculiar receptacles, which are situated on each side the mouth, and when empty are so far contracted as not to appear externally, but when filled resemble a pair of tumid bladders, having a smooth veiny surface, concealed, however, under the fur or skin of the cheeks, which bulge out extremely in this state. They are so large as to hold the quantity of a quarter of a pint, English measure.

The general size of the hamster is nearly that of a brown or Norway rat, but it is of a much thicker form, and has a short tail. Its colour is a pale reddish brown above, and black beneath. The muzzle is whitish, the cheeks reddish, and on each side the body are three moderately large oval white spots, of which those on the shoulders are the largest; the ears are moderately large and rounded, and the tail almost bare, and about three inches long; on the fore-feet are four toes, with a claw in place of a fifth, and on the hind-feet are five toes. Sometimes the hamster varies in colour, being found either black with a white muzzle, or of a pale yellowish white. The male is always much larger than the female. On each side the lower part of the back is an almost bare spot, covered only with very short down.

The hamster inhabits Siberia and the south of Russia. It is also found in Poland, as well as in many parts of Germany. They are very destructive in some districts, devouring great quantities of grain, which they carry off in their cheek-pouches, and deposite in their holes, in order to devour during the autumn. Their habitations, which they dig to the depth of three or four feet, consist of more or fewer apartments, according to the age of the animal: a young hamster makes them hardly a foot deep; an old one sinks them to the depth of four or five feet, and the whole diameter of the residence, taking in all its habitations, is sometimes eight or ten feet. The principal chamber is lined with dried grass, and serves for a lodging; the others are destined for the preservation of provisions, of which he amasses a great quantity during the autumn. Each hole has two apertures; the one descending obliquely, and the other in a perpendicular direction; and it is through this latter that the animal goes in and out. The holes of the females, who never reside with the males, are somewhat different in their arrangement, and have more numerous passages. The female breeds two or three times a year, producing five or six, and sometimes as many as sixteen or eighteen. The growth of the young is rapid, and they are soon able to provide for themselves.

The hamster feeds on all kinds of herbs and roots, as well as on grain, and even occasionally on the smaller animals. "In harvest-time (says Mr. Allamand) he makes his excursions for provision, and carries every article he can find into his granary. To facilitate the transportation of his food, nature has provided him with two pouches in the inside of each cheek. On the outside these pouches are membranous, smooth, and shining; and in the inside are a great many glands, which continually secrete a certain fluid, to preserve their flexibility, and to enable them to resist any accidents which may be occasioned by the roughness or sharpness of particular grains."

On the approach of winter the hamster retires into his subterraneous abode, the entry of which he shuts up with great care; and thus remaining in a state of tranquillity, feeds on his collected provision till the frost becomes severe; at which period he falls into a profound slumber, which soon grows into a confirmed torpidity, so that the animal continues rolled up, with all its limbs inflexible, its body perfectly cold, and without the least appearance of life. In this state it may even be opened; when the heart is seen alternately contracting and dilating, but with a motion so slow as to be scarce perceptible, not exceeding 15 pulsations in a minute, though in the waking state of the animal it beats 150 pulsations in the same time. It is added that the fat of the creature has the appearance of being coagulated, that its intestines do not exhibit the smallest symptoms of irritability on

the application of the strongest stimulants, and the electric shock may be passed through it without effect. This lethargy of the hamster has been generally ascribed to the effect of cold alone; but late observations have proved, that unless at a certain depth beneath the surface, so as to be beyond the access of the external air, the animal does not fall into its state of torpidity, and that the severest cold on the surface does not affect it. On the contrary, when dug up out of its burrow, and exposed to the air, it infallibly awakes in a few hours. The waking of the hamster is a gradual operation: he first loses the rigidity of his limbs; then makes profound inspirations, at long intervals; after this he begins to move his limbs, opens his mouth, and utters a sort of unpleasant rattling sound. After continuing these operations for some time, he at length opens his eyes, and endeavours to rise; but reels about for some time, as if in a state of intoxication, till at length, after resting a small space, he perfectly recovers his usual powers. This transition from torpidity to activity requires more or less time, according to the temperature of the air, and other circumstances. When exposed to a cold air, he is sometimes two hours in waking; but in a warmer air the change is effected in half the time.

The manners of the hamster are generally represented as far from pleasing. No society appears to exist among these animals. They are naturally very fierce, and make a desperate defence when attacked: they also pursue and destroy every animal which they are capable of conquering, not excepting even the weaker individuals of their own species. They are said to be particularly fond of the seeds of liquorice, and to abound in the districts where that plant is cultivated. According to Mr. Sultzer, they abound to such a degree in Gotha, that in one year 11,564, in another 54,429, and in a third 80,139 of their skins were delivered in the Hotel de Ville of that capital, where the hamster is proscribed on account of the devastations it commits among the corn.

13. Mus bursarius, Canada rat. This, which is a species but lately discovered, seems to be the most remarkable of all the pouched rats for the proportional size of the receptacles. It is a native of Canada, and is about the size of a brown or Norway rat, and is of a pale greyish-brown colour, rather lighter beneath; the length to the tail is about nine inches, and that of the tail, which is but slightly covered with hair, about two inches; the legs are short; the fore-feet strong, and well adapted for burrowing in the ground, having five claws, of which the three middle ones are very large and long; the interior much smaller, and the exterior very small, with a large tubercle or elbow beneath it. The claws on the hind-feet are comparatively very small, but the two middle are larger than the rest, and the interior one is scarce visible; the teeth are extremely strong, particularly the lower pair, which are much longer than the upper; the ears are very small. This species is described in the 5th volume of the Transactions of the Linnæan Society; but we must observe that by some oversight in the conduct of the figure there given, the claws on the forefeet are represented as only three in number, and are somewhat too long, weak, and curved. A more faithful representation is given in Dr. Shaw's excellent work, which is accompanied by an outline of the head, in its natural size, in order to show the teeth and cheek-pouches. The manners of this species are at present unknown; but it may be concluded that it lays in a stock of provisions, either for autumnal or winter food. The pouches of the individual specimen above described, when first brought to governor Prescot, were filled with a kind of earthy substance: it is, therefore, not improbable that the Indians who caught the animal might have stuffed it thus, in order to preserve it in its utmost extent.

14. Mus typhlus, blind rat. This is perhaps one of the largest and most remarkable of its tribe, measuring between seven and eight inches in length, and being entirely destitute both of eyes and tail; the defect of the former is a very singular circumstance, and the animal perhaps affords the only instance of a truly blind or eyeless quadruped. In the mole, the eyes, however small and deeply seated, are yet perfect in their kind, and though not calculated for acute vision, still enable the animal to avoid the danger of exposure; but in the quadruped now under consideration, there are merely a pair of subcutaneous rudiments of eyes, smaller than poppy-seeds, and covered with a real skin. It is probable, however, that even these minute organs are sufficient to give an obscure perception of light, and to enable the animal to consult its safety by generally continuing beneath the surface. The external ears are also wanting, and the foramina leading to the internal organs are very small, entirely hid by the fur, and situated at a great distance backward. There is scarce any distinction between the head and neck, and the whole form of the animal, like that of the mole, is calculated for a subterraneous life; the body being cylindric, the limbs very short, and the feet and claws, though small and weak in comparison with those of moles, yet calculated for digging or burrowing in the ground. The colour of the animal is a greyish-brown; the fur, which is very thick, soft, and downy, being dusky toward the roots, and greyish toward the tips; the head is lighter and the abdomen darker that the other parts; the lower lip is also whitish, and sometimes a white mark extends along the forehead; the front-teeth are very large, and are naturally bare or exserted; the lower pair being much longer than the upper. This singular species is a native of the southern parts of Russia, where it burrows to a great extent beneath the surface, forming several lateral passages, by which it may pass in quest of roots, &c. It is said to feed in particular on the roots of the chærophyllum bulbosum. In the morning hours it sometimes quits its hold to bask in the sunshine, and if disturbed, instantly takes refuge beneath the surface; burrowing with great agility, and frequently in a perpendicular direction. Its bite is very severe when attacked. It has no voice, but emits a kind of snorting sound, and gnashes its large teeth in a menacing manner, raising its head at the same time. The female is said to produce from two to four young.

15. Mus Capensis, Cape rat. In its general shape, this animal is not unlike the great sand rat first described, and is equally common about the Cape of Good Hope; but it is far inferior in size, measuring about seven inches to the tail, which is very short, nearly white, and flattish. The general colour of this species is a dusky rufous ash-brown, paler or more inclining to whitish beneath; the end or tip of the nose is naked and black, the

remainder white, and on each side are several strong white bristles; the chin, lower sides of the cheeks, and spaces round the eyes, are also white, and on the hind part of the head is an oval white spot; the teeth are naturally exserted or naked, and are similar in form to those of the great sand rat. In its manners and way of life, the animal is also similar to that species; and is very destructive to gardens, flinging up hillocks, and eating various kinds of roots.

MUSA, *the plantain tree*, a genus of the monœcia order, in the polyandria class of plants, and in the natural method ranking under the 8th order, scitamineæ. The calyx of the male hermaphrodite is a spatha or sheath; the corolla is dipetalous; the one petal erect and quinquedentate; the other nectariferous, concave and shorter: there are six species, five of which are perfect; one style; the germen inferior and abortive. The female hermaphrodite has the calyx, corolla, filaments, and pistil, of the male hermaphrodite, with only one filament perfect; the berry is oblong, and three-angled below. There are three species:

1. Musa paradisiaca, is cultivated in all the islands of the West Indies, where the fruit serves the Indians for bread; and some of the white people also prefer it to most other things, especially to the yams and cassada bread. The plant rises with a soft stalk 15 or 20 feet high; the lower part of the stalk is often as large as a man's thigh, diminishing gradually to the top, where the leaves come out on every side: these are often eight feet long, and from two to three broad, with a strong fleshy mid-rib, and a great number of tranverse veins running from the mid-rib to the borders. The leaves are thin and tender, so that where they are exposed to the open air, they are generally torn by the wind; for as they are large, the wind has great power against them: these leaves come out from the centre of the stalk, and are rolled up at their first appearance; but when they are advanced above the stalk, they expand and turn backward. As these leaves come up rolled in this manner, their advance upward is so quick, that their growth may almost be discovered by the naked eye: and if a fine line is drawn across level with the top of the leaf, in an hour the leaf will be near an inch above it. When the plant is grown to its full height, the spikes of flowers appear in the centre, which is often near four feet long. The flowers come out in bunches, those in the lower part of the spike being the largest; the others diminish in their size upward. Each of these bunches is covered with a sheath of a fine purple colour, which drops off when the flowers open. The upper part of the spike is made up of male flowers, which are not succeeded by fruit, but fall off with their covers. The fruit or plantain is about a foot long, and an inch and an half or two inches diameter: it is at first green, but when ripe pale-yellow. The skin is tough; and within is a soft pulp of a luscious sweet flavour. The spikes of the fruit are often so large as to weigh upwards of 40lb. The fruit of this sort is generally cut before it is ripe. The green skin is pulled off, and the heart is roasted in a clear fire for a few minutes and frequently turned: it is then scraped, and served up as bread. Boiled plantains are not so palatable.

This tree is cultivated on a very extensive scale in Jamaica, without the fruit of which, Dr. Wright says, the island would scarce be habitable, as no species of provision could supply their place. Even flour or bread itself would be less agreeable, and less able to support the laborious negro, so as to enable him to do his business, or to keep in health. Plantains also fatten horses, cattle, swine, dogs, fowls, and other domestic animals. The leaves being smooth and soft, are employed as dressings after blisters. The water from the soft trunk is astringent, and employed by some to check diarrhœas. Every other part of the tree is useful in different parts of rural economy. The leaves are used for napkins and table-cloths, and are food for hogs.

2. Musa sapientum, *the banana tree*. This species differs from the preceding in having its stalks marked with dark-purple stripes and spots. The fruit is shorter, straighter, and rounder; the pulp is softer, and of a more luscious taste. It is never eaten green; but when ripe it is very agreeable, either eaten raw or fried in slices as fritters; and is relished by all ranks of people in the West Indies. Both these plants were carried to the West Indies from the Canary Islands, whither, it is believed, they had been brought from Guinea, where they grow naturally. They are also cultivated in Egypt, and in most other hot countries, where they grow to perfection in about ten months from their first planting to the ripening of their fruit. When their stalks are cut down, several suckers come up from the roots, which in six or eight months produce fruit; so that by cutting down the stalks at different times, there is a constant succession of fruit all the year. In Europe some of these plants are raised by gentlemen who have hot-houses capacious enough for their reception, in many of which they have ripened their fruit very well; but as they grow very tall, and their leaves are large, they require more room in the stove than most people are willing to allow them. They are propagated by suckers, which come from the roots of those plants that have fruited; and many times the younger plants, when stinted in growth, also put out suckers. The fruit of this tree is four or five inches long, of the size and shape of a middling cucumber, and of a high, grateful flavour: the leaves are two yards long, and a foot broad in the middle; they join to the top of the body of the tree, and often contain in their cavities a great quantity of water which runs out upon a small incision being made into the tree, at the junction of the leaves. Bananas grow in great bunches, that weigh 12 lb. and upwards. The body of the tree is so porous as not to merit the name of wood; the tree is only perennial by its roots, and dies down to the ground every autumn. When the natives of the West Indies (says Labat) undertake a voyage, they make provision of a paste of banana, which, in case of need, serves them for nourishment and drink: for this purpose they take ripe bananas, and having squeezed them through a fine sieve, form the solid fruit into small loaves, which are dried in the sun or in hot ashes, after being previously wrapped up in the leaves of Indian flowering-reed.

3. Musa troglodytarum, has a scarlet spathe and scarlet berry, but not eatable.

MUSCA, *fly*, a genus of insects of the order diptera. The generic character is: mouth formed into a fleshy proboscis, with two lateral lips; palpi, none.

The vast extent of the genus musca makes it necessary to divide the whole into different assortments, in order to the more ready investigation of the species. These

divisions are instituted from the form of the antennæ, which are either simple (without any lateral hair or plume), or armed (that is, furnished with a lateral hair or plume). These divisions are farther separated into others, according to the more or less downy or hairy appearance of the insects.

The first section of this genus comprehends such flies as have simple antennæ.

The larvæ, in the different tribes of flies, differ far more in habit than the complete insects, some being terrestrial, and others aquatic. Those of the more common kinds are emphatically distinguished by the title of *maggots*, and spring from eggs deposited on various putrid substances. Several of the aquatic kinds are of singularly curious formation, and exhibit wonderful examples of the provision ordained by nature for the preservation of even the meanest and most seemingly contemptible of animals. Several are inhabitants of plants, feeding during this state on other living insects.

The general form of the chrysalis or pupa is that of an oval, differently modified, according to the species, and formed by the external skin of the larva, which hardens round the chrysalis. Some species, however, cast their skin before their change into the pupa state.

In this division one of the most remarkable species is the musca chamæleon, which is a large black fly, with a broad flattish abdomen, having the sides of each segment yellow, forming so many abrupt semibands across that part. It proceeds from an aquatic larva, of very considerable size, measuring two inches and a half in length, of a somewhat flattened shape, and of a brown colour, with a narrow or slender front, the body widening by degrees towards the middle, and from thence gradually tapering to the extremity or tail, which is terminated by a circle of radiating or diverging hairs. This larva is common in stagnant waters during the summer months, and passes into its chrysalis state without casting its skin, which dries over it, so as to preserve the former appearance of the animal in a more contracted state.

In this division also stands the musca vermileo, a middle-sized fly, of a somewhat lengthened form, with a distant resemblance to a tipula. It is of a dull yellow colour, with transparent wings; the thorax marked above by two black lines, and the abdomen by a triple series of black spots. The larva of this species measures above three quarters of an inch in length, and is of a pale yellowish-grey colour, slender or sharpened in front, and growing gradually broader towards the tail. It is found in the southern parts of Europe, and is not uncommon in some districts of France, and is remarkable for practising a method exactly similar to that of the hemerobius formicaleo in order to obtain its prey; excavating a circular pit or cavity in the dry sand, concealing itself beneath the centre, and thus awaiting the arrival of any small insect which may happen to fall into it, and after absorbing its juices, throwing out the exhausted remains to a considerable distance from the verge of the cavity. This larva seems to have been first observed and described by Reaumur, in the Memoirs of the French Academy for the year 1752. It assumes the state of a chrysalis by casting its skin, which rolls to the hinder part of the body: the chrysalis is of a dull reddish colour, and is rounded or clubbed at the upper part, suddenly tapering from thence to the extremity, and after lying nine or ten days, gives birth to the included insect.

Of the downy or slightly haired flies with bristled antennæ, one of the most remarkable is the musca tenax, which is about the size of a drone, and of a brown colour, with transparent wings, and the first segment of the abdomen yellowish on each side. It proceeds from a larva of a very singular appearance, being a long-tailed brown maggot, of rather slow motion, measuring about three quarters of an inch in length, exclusive of the tail, which is extensile, and consists of a double tube, the exterior annulated into numerous segments, and the interior slender, and terminated by a circle of hairs, surrounding a spiraculum or air-hole. This maggot is seen in muddy stagnant waters, drains, and other places of the dirtiest description; and notwithstanding its unpleasing appearance, exhibits, when accurately examined, many particulars well worthy of admiration. The feet in particular, which are seven in number on each side, are wonderfully calculated for enabling the animal to ascend walls or other perpendicular places, in order to seek some proper situation in which it may undergo its change into chrysalis, being very broad, and beset on their under surface with numerous small hooked claws, giving it the power of clinging with security during its ascent.

Of this larva a particularity is stated on the authority of Linnæus, which, if true, may indeed well be numbered among the Miracula Insectorum (the title of the paper in the Amœnitates Academicæ, in which it is announced), viz. that being a frequent inhabitant of the turbid pulp used in the operation of paper-making, it is often exposed to the action of the wooden mallets used in the process, as well as squeezed in the strongest presses, and yet survives uninjured these seemingly destructive operations!!!

The above larva commonly changes to a chrysalis about the end of August, the skin contracting and drying round the body, and the tail continuing in a shrivelled state. After thus remaining about the space of a fortnight, it gives birth to the complete insect, which has so much the general appearance of a drone, that it is very frequently mistaken for such. It is extremely common during the month of September.

Musca pendula, which belongs also to this division of the genus, is a moderately large and very beautiful insect. Its colour is black, with four bright yellow stripes down the thorax, and three broad interrupted bars across the abdomen; or, in other words, this fly might be described as of a bright yellow colour, with the thorax marked by four longitudinal black lines, and the abdomen by three transverse ones, connected by a black stripe down the middle. Its larva, which is an inhabitant of stagnant waters, is of a still more remarkable appearance than that of the immediately preceding species, which it resembles in size, but is of a paler colour, and furnished with a tail of greater length, composed of a double tube, the interior of which is very slender, extensile at the pleasure of the animal to a vast length, and terminated by a very small spiracle. The length of this tube is therefore varied according to the greater or smaller depth at which the insect chooses to continue, the tip reaching to the surface, in order to supply the requisite quantity of air. Sometimes great numbers of these mag-

gots are found coiled or twisted together by their tails in such a manner that it is by no means easy to separate any one from the rest. The chrysalis resembles that of the musca tenax, the remains of the tail being visible in a dried and contracted state. The complete insect is frequently seen on flowers during the autumnal season.

Among the hairy or bristly flies with plumed antennæ stands the well-known species called musca carnaria, or the common large blow-fly. This, as every one knows, deposits its eggs on animal flesh, either fresh or putrid. The larvæ or maggots hatch in about the space of a few hours, and when full-grown, which happens in eight or ten days, are of a white or yellowish-white colour with a slight tinge of pale red, and of a lengthened shape, with a sharpened front, in which the mouth is situated, and from whence the body gradually enlarges in size to the last or terminal segment, which is of a very broad and flattened form, surrounded by several slightly prominent tips, and furnished with a pair of dusky specks resembling eyes; so that an inaccurate spectator might easily mistake this part for the head, and the proper head for the tail. When the animal changes to a chrysalis, the skin dries round it, and the whole assumes a completely oval form, and a reddish colour, soon changing into a reddish-brown. In ten days more the fly itself emerges, which is too well known to require particular description.

Musca vivipara greatly resembles the preceding, and is found in similar situations, but is viviparous, disclosing small ready formed larvæ instead of eggs, which in this species are hatched internally. This particularity is not confined to the present species, but has been observed in some others of this genus.

To this as well as the preceding has been applied the observation, *Tres muscæ consumunt cadaver equi æque cito ac leo;* the number of larvæ proceeding from the flies, and the quick evolution of the successive broods, destroying the same quantity of flesh in a given time as the predacious quadruped, who devours a great quantity at certain intervals only, while the process of destruction continues with unremitted perseverance on the part of one or other of the respective races of flies.

Of the hair-flies with bristled antennæ, the musca grossa, the largest of European flies, affords a good example.

Musca flava, is one of the smallest but most elegant of the European flies; it is of a yellow colour, with bright gold green eyes.

MUSCI, *Mosses,* one of the seven families or classes into which all vegetables are divided by Linnæus in the Philosophia Botanica, is the 2d order in the cryptogamia class, according to the sexual system.

The more perfect kinds of mosses are found in the shape of small but regular plants, divided into several branches, and clothed with leaves: these are of various forms and structures; some being broad and thin, others slender as hairs; some pellucid, others opaque; some smooth, others hairy. From the alæ of these leaves in some kinds, and from the summit of the stalks in others, there arise heads or capsules of various figure and structure, but all unicapsular; some of these are naked, and others covered with a calyptra or hood; some stand on long pedicles, and others are placed close to the stalks. These heads are usually called capsulæ, which contain their seeds or farina; and their pedicles setæ, in the mnia, hypna, brya, and polytricha, &c. These capsules in some are covered with a calyptra or hood; in others they are naked. Of the first kind are the splachnum, polytrichum, mnium, bryum, hypnum, fontinalis, and buxbaumia; and of the latter sort lycopodium, porella, sphagnum, and phascum.

Some of the mosses, it is evident, approach to the nature of the plants which have their male and female parts in the same flower, and others to those which have them in different ones. After all, this tribe of plants, as well as the mushrooms, ferns, and sea-weeds, is still imperfectly known. The characteristics of these plants, however, according to the sexual system, are 1. Tops without filaments or threads. 2. The male flower, constituted by the presence of the antheræ or tops, placed apart from the female, either on the same or distinct roots. 3. The female roots, flowers deprived of the pistillum or pointal. 4. The seeds devoid of both lobes (cotyledones) and proper coverings, so that they exhibit the naked embryo.

This order is subdivided into 13 genera, from the presence or absence of the calyx, which in these plants is a veil or cover like a monk's cowl, that is placed over the male organs or tops of the stamina, and is denominated calyptra, from the sexes of the plants, which bear male and female flowers, sometimes on the same, sometimes on distinct roots; and from the manner of growth of the female flowers, which are sometimes produced singly, sometimes in bunches or cones.

The manner of seeding of mosses in general, may be more clearly understood from the description of that genus of them which has been traced through all its stages, and to which most of the others, though every genus has its distinct fructification in some respects, yet bear a very general analogy.

The genus already observed, is that called by Dr. Dillenius, the hypnum. The species of this are very numerous and common; but that particular one which was the subject of these observations, is the short-branched silky kinds, common on old walls; and called by that author in his History, hypnum vulgare, sericum, recurvum, capsulis erectis cuspidatis.

The head of this moss appears to the naked eye a small, smooth, brownish-yellow, oblong body, of about a ninth of an inch long; this is covered at its upper end with a membranaceous calyptra or hood, in shape resembling an extinguisher, or a funnel inverted. When this calyptra is taken off, and the head viewed with a microscope, the surface of it is seen to be ridged with longitudinal striæ. The basis of the head is of a deep orange-colour, and more opaque than the rest; and the top is bounded by an orange-coloured ring, swelling out something beyond the surface of the contiguous parts of the head. Good glasses show that in this head there are not wanting the parts essential to the fructification of what are usually called the more perfect plants. The ring is truly a monophyllous undulated calyx, within which arise sixteen pyramidal fimbriated stamina; these are of a pale-greenish colour, and are loaded with a whitish oval farina. The stamina all bend towards each other from their bases, and almost meet in a point at the tops. This is their appearance when the head is nearly ripe; and immediately under the arch formed by these stamina, is a cylindric hollow pistillum, through which the farina makes its way,

and is dispersed among the seeds in the head. The fruit is a large capsule, filling every part of the membrane which shows itself on the outside of the head, and in most places is contiguous to it; this capsule is filled with perfect and very beautiful seeds; they are round, transparent when unripe, but afterwards opaque, and of a very beautiful green, which colour they retain even when dried.

When this head is first produced from the plant, the stamina are very slender, and stand erect; the head is scarcely any thicker than the stalk, and the calyptra covers it all over, to shield the tender substance of the farina from external injuries. As the farina afterwards swells in the stamina, the seeds in the head increase also in bulk, and by their increase the head is more extended in thickness; and the stamina are by this means separated farther and farther from each other at their bases, but bend inwards toward their points, so as to form a kind of arched covering over the stigma of the pistillum, which is single, and hence the farina falls as it ripens into the head, and impregnates the seeds.

The 11 principal genera are as follow: lycopodium, polytrichum, bryum, selagines, usneæ, mnium, byssi, sphagnum, hypna, confervæ, and fontinales. These are found growing on the barks of trees as well as on the ground.

Many of the mosses grow on rocks and barren places, and, rotting away, afford the first principles of vegetation to other plants, which could never else have taken root there. Others grow in bogs and marshes, and by continual increase and decay fill up and convert them either into fertile pastures, or into peat-bogs, the source of inexhaustible fuel to the polar regions. They are applicable also to many domestic purposes: the lycopodiums are some of them used in dyeing of yarn, and in medicine; the sphagnum and polytrichum furnish convenient beds for the Laplanders; and the hypnums are used in tiling of houses, stopping crevices in walls, packing up of brittle wares and the roots of plants for distant conveyance, &c.

MUSCICAPA, or Fly-catcher, a genus of birds belonging to the order of passeres. The bill is flatted at the base, almost triangular, notched at the upper mandible, and beset with bristles: the toes (generally) divided as far as their origin. There are 97 species; the most remarkable are:

1. The grisola, or spotted fly-catcher, about five inches and three quarters long. The head is large, of a brownish hue, spotted obscurely with black: the back is of a mouse colour; the wings and tail are dusky; the breast and belly white. It is a bird of passage; appears here in the spring, breeds with us, and departs in September. It builds its nest against any part of a tree that will support it; often in the hollow caused by the decay of some large limb, hole in a wall, &c. also on old posts and beams of barns; and is found to return to the same place season after season. It lays four or five pale eggs marked with reddish. It feeds on insects, and collects them on the wing.

2. The flabellifera, or fan-tailed fly-catcher, is in length six inches and a half: the head is black, which colour descends on the back part lower than the nape, whence it passes forward in a narrow collar to the throat; the chin, throat, and sides of the neck, except where this collar passes, are white, and over the eye is a white streak like an eyebrow; the tail is longer than the body, the two middle feathers black, others white; the legs are dusky. This species inhabits the southern isle of New Zealand; where it is seen constantly hunting after insects, and flies always with its tail in shape of a fan. It is easily tamed; and will then sit on any person's shoulder, and pick off the flies. See Plate XCII. Nat. Hist. fig. 281.

3. The carihonensis, or cat-bird, is somewhat bigger than a lark: length eight inches: bill black; the upper parts of the body and wings are of a deep brown; the under ash-coloured; the crown of the head is black; the tail is blackish; and the legs are brown. This species is common in the United States in the summer-season; where it frequents shrubs rather than tall trees, and feeds on insects; its cry resembles that of a cat, whence the English name given it by Catesby.

4. The rubicollus, purple-throated fly-catcher, is about the size of a blackbird; the whole plumage is black, except the chin, throat, and fore part of the neck, on which is a large bed of beautiful crimson, inclining to purple; the legs are black. These birds inhabit Cayenne and other parts of South America; where they are found in flocks, and precede in general the toucans in their movements. They feed on fruits and insects; and are lively birds, always in action. They for the most part frequent the woods, like the toucans; and where the first are found, the others are seldom far off. See fig. 283.

MUSCLE. See Anatomy.

Muscles, *Insertion and force of the.* The all-wise Author of nature has furnished animals with limbs, moveable about the joints by means of muscular cords, inserted near the joint or centre of motion; the great wisdom of which will appear, from supposing the insertion to be at E (Plate XCIV. Miscel. fig. 168.) near the wrist B, the muscle D E being either loose and separate from the bone D, A, B, or bound down to it by some ligament or fascia R; in either of which cases the bone A B cannot be turned up quite to the situation A H, unless the muscle D E is contracted or shortened to D M, which would not only be troublesome but even impossible. It would be troublesome, because the breadth and thickness of the arm would be vastly increased, so as to become as big as the belly of an animal. On the other hand, the structure of a muscle being such that it cannot be contracted but a little, seldom above two or three fingers'-breadth; such an insertion as that at E, which requires a contraction of a about a foot and a half, would be altogether impossible. Therefore, in fact, we find the muscles inserted near the centre of motion, as at I, 169.

In order to calculate the force of any muscle, we are to consider the bones as levers; and then the power or force of the muscle will be always to the resistance or weight it is capable of raising, as the greater distance of the weight from the centre of motion is to the lesser distance of the power. Hence, it being found by experiments, that a robust young man is able to suspend a weight R, equal to twenty-eight pounds, when the arm is extended in a supine and horizontal situation, we have this proportion, viz. the force of the muscle I D is to the weight R, = 28lb. as the distance D C is to the distance I C. But is found, that D C, the length of the cubit and

hand, is more than twenty times greater than I C, the distance of the muscle from the centre of motion. Therefore the force of the muscle I D, must be more than twentytwenty times greater than the weight R, or more than $28 \times 20 = 560$lb.

Again, to find the force which the biceps and brachiæus muscles exert, when the humerus D A, (fig. 170.) is perpendicular to the horizon, we are first to consider what weight a man is capable of sustaining in this posture, viz. R = 35 pounds, and next the quantity of the distances C B, C I, which in this case are as 16 to 1. Therefore the force of these muscles is to the weight R = 35 pounds, as the distance C B = 16 is to the distance I C = 1; or the force is equal to 560, as before.

But what appears most wondeeful is, the force of the muscles that move the lower jaw; which, when taken altogether, do not in a man exceed the weight of 1 pound, and yet exert a force equal to 534 pounds, and in mastiff-dogs, wolves, bears, lions, &c. their force is vastly superior, so as to break large hones, as they practise daily in their feeding.

The motions of the far greater part of the muscles are voluntary, or dependant on our will; those of a few others, involuntary. The former are called animal, the other natural motions. Finally, the motions of some of the muscles are of a mixed kind, partly animal and partly natural. Those muscles which perform the voluntary motions, receive nerves from the brain or spiral marrow: those which perform their motions involuntary, have their nerves from the cerebellum; and those whose motion is partly voluntary, and partly involuntary, have theirs in part from the brain, and in part from the cerebellum. And as a muscle can no longer act when its nerve is either cut asunder or tied up, so the same absolute dependance it has on its artery: for from the experiments of Steno and others on living animals, it appears that in cutting or tying up the artery, the muscle in the same manner loses its whole power of action, as if the nerve had been cut or tied up.

MUSCOVY GLASS. See Mica.

MUSHROOM. See Agaricus.

MUSIC, a science which teaches the properties, dependances, and relations of melodious sounds; or the art of producing harmony and melody by the due combination and arrangement of those sounds. This science when employed in searching the principles of this combination and succession, and the causes of the pleasure we receive from them, becomes very profound, and demands much patience, sagacity, and depth of thinking. It is generally supposed that the word music is derived from Musa, because it is previously believed that the invention of this art is to be attributed to the muses: but Diodorus derives it from an Egyptian name, intimating that music was first established as a science in Egypt after the Deluge, and that the first idea of musical sound was received from that produced by the reeds growing on the banks of the Nile, by the wind blowing into them. Others again imagine, that the first ideas of music were received from the warbling of birds. However this may really have been, it appears at least equally rational, to attribute its origin to mankind; since musical intonation, in the infancy of language, must often have been the natural result of passionate feeling, and since also we find that wherever there is speech there is song.

The antient writers on this science differ greatly as to its object and extent. In general, they give to it a much wider latitude than that which it obtains with us. Under the name of music they comprehended not only the melodious union of voices and instruments, but also the dance, gesture, poetry, and even all the other sciences. Hermes defines music to be the general knowledge of order; which was also the doctrine of Plato, who taught that every thing in the universe was music.

Music, however, properly so called, only concerns the due order and proportion of sounds; and is divided into two parts, the theoretical and the practical. Theoretical music comprehends the knowledge of harmony and modulation; and the laws of that successive arrangement of sound by which air, or melody, is produced. Practical music is the art of bringing this knowledge and those laws into operation, by actually disposing of the sounds, both in combination and succession, so as to produce the desired effect; and this is the art of composition: but practical music may, in fact, be said to extend still further, and to include not only the production of melodious and harmonious composition, but also its performance; and to such facility in execution, and nicety of expression, has this department of practical music arrived at the present day, that its professors, generally speaking, hold a truly respectable rank in the various list of modern artists; and are highly, as well as most deservedly, esteemed by all lovers and patrons of musical taste and ingenuity.

MUSSÆNDA, a genus of the pentandria monogynia class and order. The cor. is funnel-form; stigma 2, thickish; berry oblong, inferior; seeds disposed in 4 rows. There are three species, shrubs of China.

MUSK. This substance is secreted in a gland, situated in the umbilical region of the quadruped called moschus moschifer (which see.) Its colour is brownish red; its feel unctuous; its taste bitter; and its smell aromatic and intensely strong. It is partially soluble in water, which acquires its smell; and in alchohol, but that liquid does not retain the odour of musk. Nitric and sulphuric acids dissolve it, but destroy the odour. Fixed alkalies develope the odour of ammonia. Oils do not act on it. At a read heat it has the same fetid smell as urine. Its component parts have not been ascertained.

MUSKET, a fire-arm borne on the shoulder, and used in war. The length of a musket is fixed at three feet eight inches from the muzzle to the pan, and it carries a ball of 29 to 2 pounds.

In fortification, the length of the line of defence is limited by the ordinary distance of a musket-shot, which is about 120 fathoms; and the length of almost all military architecture is regulated by this rule. See Gunnery, Gun-smithery, and Rifle.

MUSKETOON, a kind of short thick musket, whose bore is the thirty-eighth part of its length: it carries five ounces of iron, or seven and a half of lead, with an equal quantity of powder. This is the shortest sort of blunderbuss.

MUSLIN, a fine thin sort of cotton cloth, which bears a downy nap on its surface. There are several

sorts of muslins brought from the East Indies, and more particularly from Bengal.

MUSTELA, the *otter*, a genus of quadrupeds of the order feræ: the generic character is, foreteeth upper six, erect, acuter, distinct; lower six, obtuser, crowded, placed within; tongue smooth.

M. lutra, common otter. The common otter is found in almost every part of Europe, as well as in the colder regions of Asia; inhabiting the banks of rivers, and feeding principally on fish. It occurs also in the northern parts of America, and particularly in Canada, where it appear to arrive at a larger size than in Europe. In the river Euphrates, on the contrary, it is found to be no larger than a common cat; but it is probable, that this is in reality a different species, viz. the M. lutreola, or smaller otter, hereafter to be described. The length of the otter is nearly two feet from nose to tail, and of the tail about sixteen inches. Its colour is a deep brown, with a small light-coloured patch on each side the nose, and another under the chin. "The otter, (says Mr. Pennant) shows great sagacity in forming its habitation: it burrows under ground on the banks of some river or lake, and always makes the entrance of its hole under water, working upwards to the surface of the earth; and, before it reaches the top, makes several holts or lodges, that in case of high floods it may have a retreat, for no animal aff cts lying drier; and then makes a minute orifice for the admission of air. It is farther observed, that this animal, the more effectually to conceal its retreat, contrives to make even this little air-hole in the midst of some thick bush." Though the principal food of the otter consists of fish, yet it is said that in hard weather, when this its natural prey fails, it will attack the smaller quadrupeds, as well as poultry, &c. The otter is naturally a very fierce animal: and when hunted with dogs, as is sometimes the practice, will inflict very severe wounds on its antagonists. The female produces four or five young at a birth; this commonly happens early in the spring. The young otters, if taken at a very early age, may be successfully tamed, and taught by degrees to hunt for fish, and bring them to their master.

When the otter, in its natural or uneducated state, has caught a fish, it immediately draws it ashore, and devours the head and upper parts, leaving the remainder; and when in a state of captivity, will eat no fish but what is perfectly fresh, but will prefer bread, milk, &c.

2. M. lutreola, the smaller otter, very much resembles the common otter, but is smaller; the body is of a dusky colour, but with a considerable cast of tawny. In size it falls short of the common otter, measuring about a foot in length. In North America this species is known by the name of minx; and is said sometimes to leave the water, and prey on poultry, &c. in the manner of a polecat, biting off the heads and sucking the blood. It is said also to have a fetid smell. In Europe the smaller otter is chiefly found in Poland and Lithuania, living on fish, frogs, &c. Its fur is very valuable, and next in beauty to that of the sable.

3. M. lutris, the sea otter, is the largest of the otters, measuring about three feet from the nose to the tail, and the tail thirteen inches. The colour of this species is a deep, glossy, brownish black, the fur being extremely soft and very fine; on the forehead is generally a cast of greyish or silver-colour. According to Mr. Pennant, it is one of the most local animals we are acquainted with, being entirely confined between lat. 44° and 60° north; and between east long. from London, 126° to 150°; inhabiting, in great abundance, Bering's islands, Kamtschatka, the Aluetian and Fox islands, between Asia and America. They land also in the Kurile islands, but are never seen in the channel between the north-east of Siberia and America. It is supposed that they bring but one at a time. They are most extremely harmless animals, and are singularly affectionate to their young. They bring forth on land, and often carry the young one between their teeth; fondle them; and frequently fling them up, and catch them again in their paws; and before they can swim, the parents take them in their fore feet, and swim about on their backs. The young continues with its parent till it takes a mate.

This animal is killed for its skin, which is one of the most valuable of furs, being sold at the rate of from 14 to 25 pounds sterling each. They are said to be chiefly sold to the Chinese.

The sea otter is sometimes taken with nets, but is more frequently destroyed with clubs and spears.

4. M. fero, ferret, has eyes red and fiery. It inhabits Africa. In Europe it is tamed to catch rabits, rats, &c. It procreates twice a year, and brings forth from 6 to 8 at a time. See Plate XCII. Nat. Hist. fig. 284.

M. erminea, stoat: inhabits Europe, the cold parts of Africa, Asia, and China; lives in heaps of stones, banks of rivers, hollow trees, and forests, especially of beech: preys on squirrels, mice, and small birds. Body about ten inches long; hair short, which in northern climates becomes white, except the outer half of the tail, which remains black. The fur is very valuable. See fig. 286. There are 28 species of the mustela.

MUST. See FERMENTATION.

MUTE. If any person being arraigned on any indictment or appeal for felony, or any idictment for piracy, shall upon such arraignment stand mute, or will not answer directly to the felony or piracy, he shall be convicted of the offence, and the court shall thereupon award judgment and execution, in the same manner as if he had been convicted by verdict or confession; and by such judgment shall have all the same consequences as a conviction by verdict or confession. 12 G. III. c. 20.

And the law is the same with respect to an arraignment for petit treason or larceny; for before this act, persons standing mute in either of these cases, were to have the like judgment as if they had confessed the indictment. 2 Inst. 177.

MUTILLA, a genus of insects, of the order hymenoptera; the generic character is, antennæ filiform; feelers four; the articulations obconic, seated on the tip of the lip; jaw membranaceous at the tip, lip projecting obconic; wings in most species obconic; body pubescent, thorax retuse behind; sting pungent, concealed. The M. helvola inhabits the Cape of Good Hope. See Plate XCII. Nat. Hist. fig. 287. There are 38 species.

MUTISIA, a genus of the class and order syngenesia polygamia superflua. The cal. is cylindric, imbricate; cor. of the ray oval, oblong; of the disk, trifid, down-feathered; recept. naked. There is one species, a climber of Peru.

MUTUAL PROMISE, is where one man promises to pay money to another, and he, in consideration thereof, promises to do a certain act, &c. &c. Such promises must be binding, as well on one side as the other; and both made at the same time. 1 Salk. 21.

MUTUS ET SURDUS, a person dumb and deaf, and being a tenant of a manor, the lord shall have the wardship and custody of him. But if a man be dumb and deaf, and have understanding, he may be grantor or grantee of lands, &c. 1 Co. Inst.

A prisoner deaf and dumb from his birth, may be arraigned for a capital offence, if intelligence can be conveyed to him by signs or symbols. Leach's Cr. Law, 97. See EVIDENCE.

MUTULE. See ARCHITECTURE.

MUTUUM, in the civil law, denotes a loan simply so called; or a contract introduced by the law of nations, whereby a thing consisting in weight, as bullion; in number, as money; or in measure, as corn, timber, wine, &c. is given to another upon condition that he shall return another thing of the same quantity, nature, and value, on demand. This, therefore, is a contract without reward; so that where use or interest arises, there must be some particular article in the contract whereon it is founded.

MUTINY, in a military sense, to rise against authority. Any officer or soldier who shall presume to use traitorous or disrespectful words against the sacred person of his majesty, or any of the royal family, is guilty of mutiny.

Any officer or soldier who shall behave himself with contempt or disrespect towards the general or other commander in chief of our forces, or shall speak words tending to their hurt or dishonour, is guilty of mutiny.

Any officer or soldier who shall begin, excite, cause, or join in, any mutiny or sedition in the troop, company, or regiment to which he belongs, or in any other troop, or company, in our service, or on any party, post, detachment, or guard, on any pretence whatsoever, is guilty of mutiny.

Any officer or soldier, who, being present at any mutiny or sedition, does not use his utmost endeavours to suppress the same, or coming to the knowledge of any mutiny, or intended mutiny, does not, without delay, give information to his commanding officer, is guilty of mutiny.

Any officer or soldier, who shall strike his superior officer, or draw, or offer to draw, or shall lift up any weapon, or offer any violence against him, being in the execution of his office, on any pretence whatsoever, or shall disobey any lawful command of his superior officer, is guilty of mutiny. See the articles of war.

MYA, the gaper, in zoology; a genus belonging to the order of vermes testacea, the characters of which are these. It has a bivalve shell gaping at one end; the hinge, for the most part, furnished with a thick, strong, and broad tooth, not inserted into the opposite valve. This animal is an ascidia. The most remarkable species are,

1. The declivis, or sloping mya, which has a brittle half-transparent shell, with a hinge slightly prominent near the opening, and sloping downwards. It inhabits the rivers of Europe. It is frequent about the Hebrides, and the fish is eaten there by the gentry.

2. The mya pictorum, has an oval brittle shell, with a single longitudinal tooth like a lamina in one shell, and two in the other; the breadth is a little above two inches, the length one. It inhabits rivers. The shells are used to put water-colours in, whence the name. Otters feed on this and the other fresh-water shells.

3. The margaritifera, or pearl mya, has a very thick, coarse, opaque shell; often much decorticated; oblong, bending inward on one side, or arcuated; black on the outside; usual breadth from five to six inches, length two and a quarter. It inhabits great rivers, especially those which water the mountanious parts of Great Britain. This shell is noted for producing quantities of pearl. There have been regular fisheries for the sake of this precious article in several of our rivers. Sixteen have been found within one shell. They are the disease of the fish, analogous to the stone in the human body. On being squeezed they will eject the pearl, and often cast it spontaneously in the sand of the stream. The river Conway was noted for them in the days of Camden.

Linnæus made a remarkable discovery relating to the generation of pearls in this fish. It is a fish that will bear removal remarkably well; and it is said, that in some places they form reservoirs for the purpose of keeping it, and taking out the pearl, which, in a certain period of time, will be again renewed. From observations on the growth of their shells, and the number of their annular laminæ or scales, it is supposed the fish will attain a very great age; 50 or 60 years are imagined to be a moderate computation. The discovery turned on a method which Linnæus found, of putting these shell-fish into a state of producing pearls at his pleasure; though the final effect did not take place for several years: he says that in five or six years after the operation, the pearl would have acquired the size of a vetch. We are unacquainted with the means by which he accomplished this extraordinary operation.

MYAGRUM, *Gold of Pleasure*, a genus of the siliculosa order, in the tetradynamia class of plants; and in the natural method ranking under the 39th order, siliquosæ. The silicula is terminated by an oblong style; the cell generally monospermous. There are ten species; but the most remarkable is the sativum, which grows naturally in corn-fields in the south of France and Italy, and also in some parts of Britain. It is an annual plant; and is cultivated in Germany for the sake of the expressed oil of the seeds, which the inhabitants use for medicinal, culinary and economical purposes. The seeds are a favourite food with geese. Horses, goats, sheep, and cows eat the plant.

MYCTERIA, the JABIRU, a genus of birds belonging to the order of grallæ. The bill is long, bending upwards, and acute; the nostrils are small and linear; there is no tongue; and the feet have four toes. There are two species: 1. The Americana, or American jabiru, is about the size of a turkey. See Plate XCII. Nat. Hist. fig. 288. The bill is long, stout, and of a black colour; the whole plumage is white, except the head, and about two-thirds of the neck, which are bare of feathers and of a blackish colour; the remainder is also bare, and of a fine red; on the hind-head are a few greyish feathers; the legs are strong, of a great length, and covered with black scales; wings and tail even at the end. This bird is found in all

the savannas of Cayenne, Guiana, and other parts of South America. It is migratory and gregarious. It makes its nest in great trees, which grow on the borders; lays two eggs, and brings up the young in the nest till they can descend to the ground. The colour of the young birds is grey; the second year it changes to rose-colour, and the third to pure white. They are very wild and voracious, and their food is fish, which they devour in great quantities. The flesh of the young birds is said to be good eating, but that of the old is hard and oily. 2. The Asiatica, or Indian jabiru, is of a large size. The bill is dusky, almost straight above, and gibbous near the forehead; the under mandible swelled beneath; and from the base of the bill there passes through and beyond the eye a black streak. The general colour of the plumage is white: the lower half of the back, the prime quills, and tail, are black; the legs a pale red. This species inhabits the East Indies, and feeds on snails.

MYGINDA, a genus of the tetragynia order, in the tetrandria class of plants; and in the natural method ranking with those of which the order is doubtful. The calyx is quadripartite; the petals four; the fruit a globose plum. There are three species, shrubs of the West Indies.

MYOSOTIS, *Scorpion-grass*, a genus of the monogynia order, in the pentandria class of plants; and in the natural method ranking under the 41st order, asperifoliæ. The corolla is salver-shaped, quinquefid, and emarginated; the throat shut up by small arches. There are seven species, of which the most remarkable is the scorpioides, or mouse-ear. This is a weed of Britain, growing naturally in dry fields, and margins of springs and rills. The blossoms vary from a full blue to a very pale one, and sometimes a yellow; and appear in a long spirally twisted spike. When it grows in the water, and its taste and smell is thereby rendered less observeable, sheep will sometimes eat it; but it is generally fatal to them. Cows, horses, swine, and goats, refuse it.

MYOSURUS, a genus of the polyginia order, in the pentandria class of plants; and in the natural method ranking under the 26th order, multisiliquæ. The calyx is pentaphyllous, the leaves cohering at the base; there are five subulated nectaria resembling petals; the seeds are numerous. There is one species, a weed.

MYOXUS, *dormouse*, a genus of quadrupeds of the order glires: the generic character is, front teeth two, the upper cuneated, the lower compressed; grinders four in each jaw; vibrissæ long; tail cylindric, villose, thicker towards the end; legs of equal length, fore-feet tetradactylous.

1. Myoxus glis, fat dormouse; this species, the glis of Pliny and the old naturalists, is a native of France and the South of Europe. It also occurs in Russia, Austria, &c. residing on trees, and leaping from bough to bough in the manner of a squirrel, though with a less degree of agility. It feeds on nuts, acorns, fruit, &c. and during great part of the winter remains torpid in its nest, which is prepared in the hollows of trees, with dried leaves, moss, &c. During its state of torpidity, it is said to grow very fat, contrary to the nature of most of the hybernating or sleeping animals; which are observed, on their first emerging from that state, to be far leaner than before its commencement. It is probable, however, that this animal awakes at intervals, and indulges in the use of its collected stores of provision.

It is but just to observe, that the count de Buffon has very properly exposed the absurdity of the ancient notion; and has observed that the animal occasionally wakes and makes use of its stock of provision. The truth is, that it is at all times fat, and appears as much so in spring as in autumn. By the ancient Romans it was numbered among the articles of luxury, and was fattened in proper receptacles, called gliraria.

The size of this elegant species is not very far short of that of a squirrel, measuring from nose to tail near six inches, and the tail four and a half. It is an animal of a much thicker form in proportion, than a squirrel, and is of an elegant ash colour, white on the under parts and insides of the limbs; the tail is very villose or furry, and of a slightly spreading form, like that of a squirrel; the eyes are large and black; the ears thin, rounded and very slightly haired. Sometimes the upper parts of the body have a slight dusky, and sometimes a ferruginous tinge. Its general manners resemble those of a squirrel, but it is not easily tamed. The young are produced about the middle of summer, and are four or five in number.

2. Myoxus nitella, garden dormouse. The garden dormouse is a native of the temperate and warmer regions of Europe and Asia, and is commonly found in gardens feeding on various kinds of fruit, particularly peaches and apricots. It makes its nest, like the rest of this genus, in the hollows of trees, and sometimes in those of walls, or even in the ground about the roots of trees, &c. collecting, for this purpose, dried leaves, grass, mosses, &c. In autumn it collects a quantity of nuts, mast, &c. and deposits it in its hole; and during the greatest part of the winter remains in a state of torpidity, awaking only at distant intervals. Its general length is about four inches and a half, and the tail rather less. It is of an elegant rufous or ferruginous colour above, and yellowish-white beneath; the eyes are imbedded in a large black patch or spot, which extends to some distance beyond each ear; the tail is somewhat wider towards the end, and sharpens at the extremity, and is marked on that part by a longitudinal black stripe, having the edges white. These animals produce their young about the middle of summer, which are about five or six in number, and are said to be of a very quick growth.

3. Myoxus muscardinus, common dormouse. The size of this animal is nearly equal to that of a mouse, but it is of a more plump or rounded form, and the nose is more obtuse in proportion; the eyes are large, black, and prominent; the ears broad, thin, and semitransparent; the fore-feet have four toes, and the hind-feet five, but the interior of these latter are destitute of nails; the tail is about two inches and a half long, and is closely covered on all sides with hair, which is rather longer towards the tip than on the other parts; the head, back, sides, belly, and tail, are of a tawny-red colour; the throat white; the fur is remarkably soft, and the whole animal has a considerable degree of elegance in its appearance. It sometimes happens that the colour is rather brown than reddish.

Dormice, says Mr. Pennant, inhabit woods or very thick hedges; forming their nests in the hollows of some low tree, or near the bottom of a close shrub. As they

want much of the sprightliness of the squirrel, they never aspire to the tops of trees, or attempt to bound from spray to spray. Like the squirrel, they form little magazines of nuts, &c. for their winter provision, and take their food in the same upright posture. The consumption of their hoard during the rigour of winter is but small, for they sleep most part of the time, retiring into their holes on the approach of winter, and rolling themselves up, lie torpid during the greatest part of the gloomy season. Sometimes they experience a short revival in a warm sunny day; when they take a little food, and then relapse into their former state.

These animals seldom appear far from their retreats, or in any exposed situation; for which reason they seem less common in this country than they really are. They make their nests of grass, moss, and dead leaves. According to the count de Buffon, it consists of interwoven herbs, and is six inches in diameter, open only above, and is situated between the branches of hazel and brushwood. The number of young is generally three or four.

MYRICA, *Gale*, or *Sweet-willow*, a genus of the tetrandria order, in the diœcia class of plants; and in the natural method ranking under the 5th order, amentaceæ, The scale of the male catkin is in the form of a crescent, without any corolla. The scale of the female catkin the same: there is no corolla; but two styles, and a monospermous berry.

1. The gale, Dutch myrtle, or sweet-willow, grows naturally upon bogs in many places both of Scotland and England. It rises about four feet high. The female flowers or catkins are produced from the sides of the branches, growing upon separate plants from the male, which are succeeded by clusters of small berries, each having a small seed. It flowers in July, and ripens in autumn. When transplanted into shrubberies, the moistest parts must be assigned to it.

The leaves, flowers and seeds of this plant, have a strong fragrant smell, and a bitter taste. They are said to be used among the common people for destroying moths and cutaneous insects, being accounted an enemy to insects of every kind; internally, in infusions, as a stomachic and vermifuge; and as a substitute to hops for preserving malt liquors, which they render more inebriating, and of consequence less salubrious; it is said that this quality is destroyed by boiling.

2. The cerifera, wax-bearing myrica, or candleberry myrtle, is a native of North America. It is a small tree, about 10 or 12 feet high, with crooked stems branching forth near the ground irregularly. The leaves grow irregularly on them all round; sometimes by pairs, sometimes alternately, but generally at unequal distances. The branches of the old plants shed their leaves in the autumn; but the young plants raised from seeds retain them the greatest part of the winter, so as during that season to have the appearance of an evergreen. But this beauty will not be lasting, for they shed their leaves proportionably earlier as the plants get older. There are both male and female trees of this sort: the flowers are small, of a whitish colour, and make no figure; neither does the fruit that succeeds the female (which is a small, dry blue berry), though produced in a clusters, make any show: so that it is from the leaves this tree receives its beauty and value; for these being bruised, as well as the bark of the young shoots, emit the most refreshing and delightful fragrance, that is exceeded by no myrtle, or any other aromatic shrub. See Plate XCII. Nat. Hist. fig. 289.

There is a variety of this species of lower growth, with shorter but broader leaves, and of equal fragrance. This grows commonly in Carolina; where the inhabitants collect from its berries a wax of which they make candles, and which occasions its being called candleberry tree. It delights in a moistish soil. The wax is procured in the following manner: In November and December, when the berries are ripe, a man with his family will remove from home to some island or sand-bank near the sea, where these trees most abound, taking with them kettles to boil the berries in. He builds a hut with palmetto-leaves for the shelter of himself and family during his residence there, which is commonly four or five weeks. The man cuts down the trees, while the children strip off the berries into a porridge-pot; and having put water to them, they boil them till the oil floats, which is then skimmed off into another vessel. This is repeated till no more oil appears. When cold, this hardens to the consistence of wax, and is of a dirty-green colour. They then boil it again, and clarify it in brass kettles; which gives it a transparent greenness. These candles burn a long time, and yield a grateful smell. They usually add a fourth part of tallow, which makes them burn clearer. There are seven other species.

MYRIOPHYLLUM, a genus of the polyandria order, in the monœcia class of plants; and in the natural method ranking under the 15th order, inundatæ. The male calyx is tetraphyllous; there is no corolla; the stamina are eight in number. The female calyx is tetraphyllous; the pistils four; there is no stile; and four naked seeds. There are two species, aquatics of Europe.

MYRISTICA, the nutmeg-tree; in botany, a genus of plants belonging to the class diœcia, and order syngenesia, and of the natural order lauri. The male calyx is monophyllous, strong, and parted into three laciniæ of an oval shape, and ending in a point: it has no corolla. In the middle of the receptacle rises a column of the height of the calyx; to the upper part of which the antheræ are attached. They vary in number from three to twelve or thirteen. The female calyx and corolla, as in the male, on a distinct tree. The germen of an oval shape; the style short, with a bifid stigma, the laciniæ of which are oval and spreading. The fruit is of that sort called drupa. It is fleshy, roundish, sometimes unilocular, sometimes bivalved, and when ripe bursts at the side. The seed is enveloped with a fleshy and fatty membraneous substance, which divides into filaments: this, in one of the species is the mace of the shops. The seed or nutmeg is round or oval-shaped, unilocular, and contains a small kernel, variegated on the surface by the fibres running in the form of a screw.

There are five species of this genus according to some authors; but several of these being only varieties, may be reduced to three, viz. 1. Myristica fatua, or wild nutmeg; this grows in Tobago, and rises to the height of an apple-tree; has oblong, lanceolated, downy leaves, and hairy fruit; the nutmeg of which is aromatic, but when given inwardly is narcotic, and occasions drunkenness, delirium, and madness for a time. 2. The myristica sebif[illegible] tree frequent in Guiana, rising to 40 or even to [illegible]

high; on wounding the trunk of which, a thick, acrid, red juice runs out. Aublet says nothing of the nutmegs being aromatic; he only observes that a yellow fat is obtained from them, which serves many economical and medical purposes, and that the natives make candles of it. 3. The mysteria aromatica, or nutmeg, attains the height of 30 feet, producing numerous branches, which rise together in stories, and covered with bark, which of the trunk is a reddish brown, but that of the young branches is of a bright green colour; the leaves are nearly elliptical, pointed, undulated, obliquely nerved, on the upper side of a bright green, on the under whitish, and stand alternately upon footstalks; the flowers are small, and hang upon slender peduncles, proceeding from the axillæ of the leaves: they are both male and female upon separate trees.

The nutmeg has been supposed to be the comacum of Theophrastus, but there seems little foundation for this opinion; nor can it with more probability be thought to be the chrysobalanos of Galen. Our first knowledge of it was evidently derived from the Arabians; by Avicenna it was called jiausiban, or jausiband, which signifies nut of Banda.

There are two kinds of nutmegs, the one male and the other female. The female is that in common use; the male is longer and more cylindric, but it has less of the fine aromatic flavour than the other. This is very subject to be worm-eaten, and by the Dutch it is strictly prohibited from being packed with the others, because it will give occasion to their being worm-eaten too, by the insects getting from one species to the other. An almost exclusive and very lucrative trade in nutmegs from the island of Ceylon was carried on by the Dutch, but it is now transferred to the English, who have become masters of the colony.

The seeds or kernels called nutmegs are well known, as they have been long used both for culinary and medical purposes. Distilled with water, they yield a large quantity of essential oil, resembling in flavour the spice itself; after the distillation, an insipid subaceous matter is found swimming on the water; the decoction inspissated, gives an extract of an unctuous, very lightly bitterish taste, and with little or no astringency. Rectified spirit extracts the whole virtue of nutmegs by infusion, but elevates very little of it in distillation; hence the spirituous extract possesses the flavour of the spice in an eminent degree.

Nutmegs, when heated, yield to the press a considerable quantity of limpid yellow oil, which on cooling concretes into a subaceous consistence. In the shops we meet with three sorts of unctuous substances, called oil of mace, though really expressed from the nutmeg. The best is brought from the East Indies in stone jars; this is of a thick consistence, of the colour of mace, and has an agreeable fragrant smell; the second sort, which is paler-coloured, and much inferior in quality, comes from Holland in solid masses, generally flat, and of a square figure: the third, which is the worst of all, and usually called common oil of mace, is an artificial composition of sevum, palm oil, and the like, flavoured with a little genuine oil of nutmeg.

Method of gathering and preparing nutmegs.—When the fruit is ripe, the natives ascend the trees, and gather it by pulling the branches to them with long hooks. Some are employed in opening them immediately, and in taking off the green shell or first rind, which is laid together in a heap in the woods, where in time it putrefies. As soon as the putrefaction has taken place, there spring up a kind of mushrooms, called boleti moschatyni, of a blackish colour, and much valued by the natives, who consider them as delicate eating. When the nuts are stripped of their first rind, they are carried home, and the mace is carefully taken off with a small knife. The mace, which is of a beautiful red, but afterwards assumes a darkish red colour, is laid to dry in the sun for the space of a day, and is then removed to a place less exposed to his rays, where it remains for eight days that it may soften a little. They afterwards moisten it with sea-water, to prevent it from drying too much, or from losing its oil. They are careful, however, not to employ too much water, lest it should become putrid, and be devoured by the worms. It is last of all put into small bags, and squeezed very close.

The nuts, which are still covered with their ligneous shell, are for three days exposed to the sun, and afterwards dried before a fire, till they emit a sound, when they are shaken; they then beat them with small sticks in order to remove their shell, which flies off in pieces. These nuts are distributed into three parcels; the first of which contains the largest and most beautiful, which are destined to be brought to Europe; the second contains such as are reserved for the use of the inhabitants; and the third contains the smallest, which are irregular or unripe. These are burnt; and part of the rest is employed for procuring oil by pressure. A pound of them commonly gives three ounces of oil, which has the consistence of tallow, and has entirely the taste of nutmeg. Both the nut and mace, when distilled, afford an essential, transparent, and volatile oil, of an excellent flavour.

The nutmegs which have been thus selected, would soon corrupt if they were not watered, or rather pickled with lime water made from calcined shell-fish, which they dilute with salt water till it attains the consistence of fluid pap. Into this mixture they plunge the nutmegs, contained in small baskets, two or three times, till they are completely covered over with the liquor. They are afterwards laid in a heap, where they heat, and lose their superfluous moisture by evaporation. When they have sweated sufficiently, they are then properly prepared, and fit for a sea-voyage.

The medicinal qualities of nutmegs are supposed to be aromatic, anodyne, stomachic, and astringent; and with a view to the last mentioned effects, it has been much used in diarrhœas and dysenteries. To many people the aromatic flavour of nutmeg is very agreeable; they however should be cautious not to use it in large quantities, as it is apt to affect the head, and even to manifest an hypnotic power in such a degree as to prove extremely dangerous. Bontius speaks of this as a frequent occurrence in India; and Dr. Cullen relates a remarkable instance of this soporific effect of the nutmeg, which fell under his own observation, and hence concludes, that in apoplectic and paralytic cases this spice may be very improper. He observes that a person by mistake took two drams or a little more of powdered nutmeg; he felt it warm in his stomach, without any

uneasiness; but in about an hour after he had taken it he was seized with a drowsiness, which gradually increased to a complete stupor and insensibility; and not long after he was found fallen from his chair, lying on the floor of his chamber in the state mentioned. Being laid abed he fell asleep; but waking a little from time to time, he was quite delirious; and he thus continued alternately sleeping and delirious for several hours. By degrees, however, both these symptoms diminished; so that in about six hours from the time of taking the nutmeg he was pretty well recovered from both. Although he still complained of head-ache, and some drowsiness, he slept naturally and quietly the following night, and next day was quite in his ordinary health.

The officinal preparations of nutmeg are, a spirit and essential oil; and the nutmeg in substance roasted, to render it more astringent. Both the spice itself and its essential oil enter several compositions, as the confectio aromatica, spiritus ammoniæ, com., &c. Mace possesses qualities similar to those of the nutmeg, but is less astringent, and its oil is supposed to be more volatile and acrid.

MYRMECIA, a genus of the class and order tetrandria monogynia; the calyx is tubular, five-toothed; cor. one-petalled; germ five glands at the base; stigma bilamelate; caps. two-valved. There is one species, a shrub of Guiana.

MYRMECOPHAGA, Ant-eater, a genus of quadrupeds of the order bruta. The generic character is, teeth none; tongue cylindric, extensile; mouth lengthened into a somewhat tubular form; body covered with hair. The animals of this genus live entirely on insects, more particularly on the various kinds of ants; in order to obtain which, they extend their tongue, which is of a very great length, and of a roundish or worm-like form, into the nests of those insects; and when, by means of the viscid moisture with which it is covered, a sufficient number are secured, they retract it suddenly into the mouth, and swallow them. A part of the generic character of the myrmecophaga is the total want of teeth, in which particularity it resembles no other animals except those of the genus manis, in which the same circumstance takes place. There are, however, in the ant-eaters, according to the observations of Mons. Broussonet, certain bones or processes not unlike teeth, situated deep at the entrance of the gullet or œsophagus; or rather, according to the celebrated Camper, at the lower end of the jaws. The species of ant-eaters are not numerous.

1. Myrmecophaga jubata, great ant-eater. This is by far the largest of the ant-eaters, being upwards of seven feet in length, from the tip of the nose to the end of the tail; but if measured to the origin of the tail, it is no more than about five feet and a half. It is an animal of an uncouth appearance; the head is small; the snout very long; the eyes small; the ears short and round; the shoulders thick and muscular, from whence the body tapers towards the tail; but the thighs are thick and stout; the colour of the animal is a deep grey, with a very broad band of black running from the neck downwards on each side the body, growing gradually narrower as it passes down; this black band is accompanied on the upper part by a streak of white; the fore legs are of a lighter cast than the hinder; and have a patch or spot of black in front not much above the foot; the tail is black, extremely long and bushy; the hair on the whole body, but especially on the tail, is very harsh and coarse: there are four toes on the fore-feet, and five on the hind: the two middle claws of the fore feet are extremely large and strong; which render this creature, though destitute of teeth, a very formidable adversary; since it has been known to destroy animals of much greater apparent strength than itself; fixing its claws upon them, and exerting such powerful strength as to kill them by continued laceration and pressure. It is a native of Brasil and Guiana; it is chiefly a nocturnal animal, and is said to sleep during the greatest part of the day in retired places. Its pace is somewhat slow, and its manners dull and heavy. It is said to swim with ease; at which time it flings its tail over its back. A living specimen was some years ago brought into Spain, and kept in the royal menagerie at Madrid; in this state of confinement it would readily eat raw meat cut small, and was said to swallow four or five pounds in a day. Its length was six feet, from the nose to the end of the tail, and its height was two feet.

2. Myrmecophaga didactyla, little ant-eater. This is an animal of great elegance. It is not superior in size to a squirrel; measuring little more than seven inches from the nose to the tail, which is longer than the body and head: the head is small; the snout sharpened, and slightly bent downwards; the legs are short; the fore feet have only two claws on each, the exterior one much larger and stronger than the interior; on each of the hind feet are four claws of moderate size; the ears are very small, and hid in the fur; the eyes are also small. The whole animal is covered with a beautiful soft, and somewhat crisped or curled fur, of a pale yellow colour, or rather yellow-brown; the tail, which is very thick at the beginning or base, gradually tapers to the tip; and the lower surface, for about the space of four inches from the tip, is bare; the tail in this species being prehensile, and the animal commonly residing on trees, and preying on ants, by means of its long tongue, in the manner of other species. It is a native of Guiana. See Plate XCII. Nat. Hist. fig. 290.

3. Myrmecophaga aculeata, aculeated ant-eater. The aculeated ant-eater is one of those curious animals which have been lately discovered in the vast island, or rather continent, of Australasia or New Holland; and is a striking instance of that beautiful gradation, so frequently observed in the animal kingdom, by which creatures of one tribe or genus approach to those of a very different one. It forms a connecting link between the very distant Linnæan genera of hystrix (porcupine) and myrmecophaga (ant-eater), having the external coating and general appearance of the one, with the mouth and peculiar generic characters of the other. This animal, so far as may be judged from the specimens hitherto imported, is about a foot in length. In its mode of life this animal resembles the rest of the ant-eaters, being generally found in the midst of some large ant-hill: it burrows with great strength and celerity under ground when disturbed; its feet and legs being most excessively strong and short, and wonderfully adapted to this purpose. It will even burrow under a

pretty strong pavement, removing the stones with its claws; or under the bottom of a wall. During these exertions, its body is strengthened or lengthened to an uncommon degree, and appears very different from the short or plump aspect which it bears in its undisturbed state.

It cannot escape the observation of every scientific naturalist, that, in consequence of the discovery of this curious animal, the Linnæan character of myrmecophaga is, in part, rendered inapplicable. Since, therefore, the genera of manis and myrmecophaga differ only in the external covering (the former being coated with scales, and the latter with hair), it would, perhaps, be not improper to conjoin the two genera, to add this as a new species, and to give as part of the generic character, corpus pilis, squamis, vel aculeis tectum. Or it might even constitute a new genus, which would differ from those of manis and myrmecophaga, in having the body covered with spines.

MYRMELEON, a genus of insects of the order neuroptera: the generic character is, mouth furnished with jaws, teeth two; feelers four, elongated; stemmata none; antennæ clavated, of the length of the thorax; wings deflected; tail of the mail furnished with a forceps consisting of two straightish filaments. Of this genus the species whose history is best understood is the myrmeleon formicaleo of Linnæus, whose larva has long been celebrated by naturalists for its wonderful ingenuity, in preparing a kind of pitfal or deceptive cavity for the destruction of such insects as happen unwarily to enter it. The myrmeleon formicaleo, in its complete or fly state, bears no inconsiderable resemblance to a small dragon-fly, from which, however, it may readily be distinguished by its antennæ. It is of a predacious nature, flying chiefly by night, and pursuing the smaller insects in the manner of a libellula. It deposits its eggs in dry sandy situations; and the young larvæ, when hatched, begin separately to exercise their talent of preparing, by turning themselves rapidly round, a very small conical cavity in the sand. Under the centre of the cavity the little animal conceals itself, suddenly rushing forth at intervals in order to seize any small insect which, by approaching the edge of the cavity, has been so unfortunate as to fall in; and after sucking out its juices through its tubular forceps, throws it by a sudden exertion to some distance from the cavity. As the creature increases in size it enlarges the cavity, which at length becomes about two inches or more in diameter. The larva, when full-grown, is more than half an inch long, and is of a flattened figure, broad towards the upper part, and gradually tapering to an obtuse point at the extremity. It is of a brown colour, and beset with numerous tufts of dusky hair, which are particularly conspicuous on each side the annuli of the abdomen; the legs are slender; the head and thorax rather small: the tubular jaws long, curved, serrated internally, and very sharp-pointed. The whole animal is of an unpleasing aspect, and on a cursory view bears a general resemblance to a flat-bodied spider. When magnified, its appearance is highly uncouth.

The ingenious Reaumur and Roesel have given accurate descriptions of this larva and its extraordinary history. It is one of those whose term of life, like that of the libellulæ and ephemeræ, is protracted to a very considerable space, since it survives the first winter in its larva state, taking no nourishment during that time, and in the spring resumes its usual manner of preying. In preparing its pit, it begins by tracing an exterior circle of the intended diameter of the cavity, continuing its motion, in a spiral line, till it gets to the centre, thus marking several volutes in the sand, resembling the impression of a large helix or snail-shell; and after having sufficiently deepened the cavity by a repetition of this motion, it smooths the sides into a regular shape by throwing out the superfluous sand lying on the ridges; this it does by closing its forceps in such a manner, that together with the head, they form a convenient shovel, with which it throws the sand with so strong a motion out of the cavity, that the grains often fall to the distance of near a foot beyond the brink. The depth of the pit is generally equal to the diameter. When full-grown and ready to change into a chrysalis, the animal envelopes itself in a round ball of sand, agglutinated and connected by very fine silk, which it draws from a tubular process at the extremity of the body; with this silk it also lines the internal surface of the ball, which, if opened, appears coated by a fine pearl-coloured silken tissue. It continues in the state of chrysalis about four weeks, and then gives birth to the complete insect.

The myrmeleon barbarus has antennæ as long as the body; thorax spotted with yellow. See Plate XCII. Nat. Hist. fig. 291.

MYROBALANS, a kind of medicinal fruit brought from the Indies. See Materia Medica.

MYRODENDRUM, a genus of the class and order polyandria monogynia. The cor. is five-petalled; stigma, capitate, five-lobed; per. five-celled. There is one species, a tree of Guiana.

MYRODIA, a genus of the monadelphia polyandria class and order; the calyx is single, one-leafed; cor. five-petalled; pist. one-leafed; cor. five-petalled; pist. one column of anthers undivided, drupe dry, two nuts. There are two species, shrubs of the West Indies.

MYROSMA, a genus of the monandria monogynia class and order; the cal. is double, outer three-leaved, inner three-parted; cor. five-parted: caps. three-cornered. There is one species, a shrub of Surinam.

MYROXYLUM, a genus of the monogynia order, in the decandria class of plants. The calyx is campanulated; the superior petal larger than the rest; the germ. is longer than the corolla; the legumen monospermous. There is but one species, the peruiferum, a native of Peru and the warmer parts of Africa. It is this shrub that yields the balsam of Peru, which is said to be extracted from it by decoction in water. This balsam, as brought to us, is nearly of the consistence of thin honey, of a reddish-brown colour inclining to black, an agreeable aromatic smell, and a very hot biting taste. Distilled with water, it yields a small quantity of a fragrant essential oil of a reddish colour; and in a strong fire, without addition, a yellowish-red oil. Balsam of Peru is a very warm aromatic medicine, considerably hotter and more acrid than copaiva. (See Balsam.) Its principal effects are to warm the habit, to strengthen the nervous system, and attenuate viscid humours. Hence its use in some kinds of asthmas, gonorrhœas, dysenteries, and

other disorders proceeding from a debility of the solids, or sluggishness and inactivity of the juices. It is also employed externally, for cleansing and healing wounds and ulcers, and sometimes against palsies and rheumatic pains. There is another sort of balsam of Peru of a white colour, and considerably more fragrant than the former. This is very rarely brought to us. It is said to be the produce of the same plant which yields the common or black balsam; and to exsude from incisions made in the trunk, while the former is obtained by boiling. There is also a third kind, commonly called the red or dry. This is supposed to obtain a different state from the white, merely in consequence of the treatment to which it is subjected after it is got from the tree. It is almost as fragrant as the balsam of Gilead, held in so high esteem among the eastern nations. It is very rarely in use in Britain, and almost never to be met with in our shops.

MYRRH, a gummy resinous concrete juice. The plant from which this substance is obtained, is not certainly known. According to Bruce, it belongs to the genus mimosa, and grows in Abyssinia and Arabia. It is in the form of tears. Colour reddish-yellow, sometimes transparent, but more frequently opaque. Taste brittle and aromatic. Does not melt when heated, and burns with difficulty. With water it forms a yellow solution. The solution in alcohol becomes opaque when mixed with water. By distillation it yields oil. Its specific gravity is 1.36. It is employed in medicine, and is soluble in alkalies.

The medical effects of this aromatic bitter are, to warm and strengthen the visera; it frequently occasions a mild diaphoresis, and promotes the fluid secretions in general. Hence it proves serviceable in languid cases, diseases arising from a simple inactivity, cachectic disorders, and where the lungs and thorax are oppressed by viscid phlegm.

Rectified spirit extracts the fine aromatic flavour and bitterness of this drug, and does not elevate any thing of either in evaporation; the gummy substance left by this menstruum has a disagreeable taste, with scarcely any of the peculiar flavour of the myrrh; this part dissolves in water, except some impurities which remain. In distillation with water, a considerable quantity of a ponderous essential oil arises, resembling in flavour the original drug. Myrrh is the basis of an officinal tincture. It enters the pilulæ ex aloe et myrrha, the pilulæ e gummi, the pilulæ stomachicæ, and other formulæ.

MYRSINE, a genus of the monogynia order, in the pentandria class of plants, and in the natural method ranking under the 18th order, bicornes. The corolla is semiquinquefid and connivent; the germen filling the corolla; the berry quinquelocular and pentaspermous. There are two species, herbs of the Cape.

MYRTLE, See Myrtus.

MYRTUS, the myrtle; a genus of the monogynia order in the icosandria class of plants; and in the natural method ranking under the 19th order, hesperidæ. The calyx is quinquifid, superior; there are five petals; the berry is dispermous or trispermous. There are 36 species, of which the most remarkable are:

1. The communis, or common myrtle-tree, of which the most material varieties are: broad-leaved Roman myrtle, with oval, shining, green leaves, an inch and a half long, and one broad; and which is remarkably floriferous. Gold-striped broad-leaved Roman myrtle. Broad-leaved Dutch myrtle, with spear-shaped, sharp-pointed, dark-green leaves, an inch long, and about three quarters of one broad. Double-flowered Dutch myrtle. Broad-leaved Jew's myrtle, having the leaves placed by threes at each joint; by which particular circumstance this species is in universal estimation among the Jews in their religious ceremonies, particularly in decorating their tabernacle; and for which purpose many gardeners about London cultivate this variety with particular care to sell to the above people: for the true sort, having the leaves exactly by threes, is very scarce, and is a curiosity; but by care in its propagation, taking only the perfectly ternate-leaved shoots for cuttings, it may be increased fast enough; and is worth the attention of the curious, and particularly those who raise myrtles for the London markets. Orange-leaved Spanish myrtle, with oval spear-shaped leaves, an inch and a half long or more, and one broad, in clusters round the branches, and resembling the shape and colour of orange-tree leaves. Gold-striped-leaved orange myrtle. Common upright Italian myrtle, with its branches and leaves growing more erect, the leaves oval, lanceolate-shaped, acute-pointed, and near an inch long and half one broad. Silver-striped upright Italian myrtle. White-berried upright Italian myrtle. Portugal acute-leaved myrtle, with spear-shaped, oval, acute-pointed leaves, about an inch long. Box-leaved myrtle, with weak branches, and small, oval, obtuse, lucid-green, closely-placed leaves. Striped box-leaved myrtle. Rosemary-leaved myrtle. Silver-striped rosemary-leaved myrtle. Thyme-leaved myrtle, with very small closely-placed leaves. Nutmeg-myrtle, with erect branches and leaves; the leaves oval, acute-pointed, and finely scented like a nutmeg. Broad-leaved nutmeg-myrtle. Silver-striped-leaved ditto. Cristated or cock's-comb myrtle, frequently called bird's-nest myrtle. These are all beautiful evergreen shrubs, of exceeding fragrance, exotics originally of the southern parts of Europe, and of Asia and Africa, and consequently in this country require a shelter of a greenhouse in winter.

2. The pimenta, pimento, Jamaica pepper, or allspice tree, grows about thirty feet in height and two in circumference; the branches near the top are much divided and thickly beset with leaves, which by their continual verdure always give the tree a beautiful appearance; the bark is very smooth externally, and of a grey colour; the leaves vary in shape and in size, but are commonly about four inches long, veined, pointed, elliptical, and of a deep shining green colour; the flowers are produced in bunches or panicles, and stand upon subdividing or trichotomous stalks, which usually terminate the branches; the calyx is cut into four roundish segments: the petals are also four, white, small, reflex, oval, and placed opposite to each other between the segments of the calyx; the filaments are numerous, longer than the petals, spreading, of a greenish-white colour, and rise from the calyx and upper part of the germen; the antheræ are roundish, and of a pale yellow colour; the stile is smooth, simple, and erect; the stigma is obtuse; the germen becomes a round succulent berry, containing two kidney-shaped flattish seeds. This tree is a native of New Spain and the West

India islands. In Jamaica it grows very plentifully; and in June, July, and August, puts forth its flowers, which, with every part of the tree, breathe an aromatic fragrance. The berries when ripe are of a dark purple colour, and full of a sweet pulp, which the birds devour greedily. The pimento is a most beautifel odoriferous evergreen, and exhibits a fine variety in the stove at all seasons.

MYTILUS, the *mussel*, a genus of animals belonging to the order of vermes testacei. The animal is an ascidia; the shell bivalve, often affixed to some substance by a beard; the hinge without a tooth, marked by a longitudinal hollow line. Of these animals there are a great many species, some of them inhabiting the seas, others the rivers and ponds. Several of them are remarkable for the beauty of their internal shell, and for the pearls which are sometimes found in them.

1. The edulis, or edible mussel, has a strong shell, slightly incurvated on one side, and angulated on the other. The end near the hinge is pointed, the other rounded. When the epidermis is taken off it is of a deep-blue colour. It is found in immense beds, both in deep water and above low-water mark. This species inhabits the European and Indian seas. Between the tropics it is largest, and smaller within the polar circle. It is said to be hurtful if too often eaten, or in too great quantities.

2. The anatinus, or duck mussel, has a shell more oblong and less convex than the last; is very brittle and semitransparent; the space round the hinges like the last; the length about five inches, breadth two. It is found in Europe in fresh waters. Both it and the cygneus are devoured by swans and ducks, whence their names: crows also feed on these mussels; as well as on different other shell-fish; and it is diverting to observe, that when the shell is too hard for their bills they fly with it to a great height, drop the shell on a rock, and pick out the meat when the shell is fractured by the fall.

3. The violacea, or violet mussel, has the shell longitudinally furrowed, the rim very obtuse, somewhat formed like the mytilus edulis, but considerably larger and more flattened, of a beautiful violet-colour. Inhabits the southern ocean.

4. The margarite ferus produces the true mother-of-pearl, and frequently the most valuable pearls: the outside sometimes sea-green, or chesnut, or bloom-colour with white rays; when the outer coat is removed it has the same lustre as the inside: the younger shells have ears as long as the shell, and resemble scallops.

There are between 50 and 60 other species.

Mussels not only open and shut their shells at pleasure, but they have also a progressive motion; they can fasten themselves where they please; they respire water like the fishes; and some even flutter about on its surface so as to inhale air. If they lie in shallow places a small circular motion is seen above the heel of the shell, and a few moments after they cast out the water by one single stroke at the other end of the shell. The mouth is situated near the sharp angle of the animal; and is furnished with four floating fringes in the shape of mustachios, which may perhaps answer the purpose of lips. The barbs which surround the edge of almost half the mussel, are a wonderful web of hollow fibres which serve as fins or organs of respiration, as vessels for the circulation of the fluids; and probably, as some philosophers suppose, as wedges for opening their shells; for we observe two large muscles or tendons for the purpose of shutting them; but we in vain look for their antagonists, or those which are destined to open them. When the mussel wishes to open itself, it relaxes the two muscles or tendons, and swells the fringes, which act as wedges, and separate the shells. The animal shuts up itself by the contraction of two thick fibrous muscles, which are fixed internally to each end of the shells; and these shells are lined all round with a membrane or epidermis, which unites them so closely together when they are soaked in water, that not the smallest drop can escape from the mussel. When mussels choose to walk they often contrive to raise themselves on the sharp edge of their shells, and put forth a fleshy substance susceptible of extension, which serves them as a leg to drag themselves along, in a kind of groove or furrow which they form in the sand or mud, and which supports the shell on both sides. In ponds these furrows are very observable. From the same member or leg hang the threads by which the animals fasten themselves to rocks, or to one another.

According to the observations of M. Mery, of the Paris academy, and the subsequent experiments of other naturalists, mussels are all androgynous; and, from a peculiar generative organization, each individual is of itself capable of propagating its species, and annually does it without the intercourse of any other. This is altogether singular, and different from what takes place in snails, earth-worms, and other androgenous or hermaphroditical animals. In the spring, mussels lay their eggs; there being none found in them but in winter. The minute eggs, or embryos, are by the parent placed in due order, and in a very close arrangement on the outside of the shell; where by means of a gluey matter, they adhere very fast, and continually increase in size and in strength, till becoming perfect mussels, they fall off and shift for themselves, leaving the holes where they were placed behind them. This abundance the mussel-shells very plainly show, when examined by the microscope, and sometimes the number is 2000 or 3000 on one shell; but it is not certain that these have been all fixed there by the mussel within; for these fish usually lying in great numbers near one another, the embryos of one are often affixed to the shell of another. The fringed edge of the mussel, which Lewenhoeck calls the beard, has in every the minutest part of it such variety of motions as is inconceivable; for being composed of longish fibres, each fibre has on both sides a vast many moving particles.

The mussel is infested by several enemies in its own element; according to Reaumur it is in particular the prey of a small shell-fish of the trochus kind. This animal attaches itself to the shell of the mussel, pierces it with a round hole, and introduces a sort of tube, five or six lines long, which it turns in a spiral direction, and with which it sucks the substance of the mussel. Mussels are also subject to certain diseases, which have been supposed to be the cause of those bad effects which sometimes happen from the eating of them.

MYXINE, the hag; a genus of insects belonging to the order of vermes intestini. It has a slender body, carinated beneath; mouth at the extremity, cirrated; the two jaws pinnated; an adipose or rayless fin round the tail and under the belly. The only remarkable species is the gluti-

nosa, about eight inches long. It inhabits the ocean; enters the mouths of fish when on the hooks of lines that remain a tide under water; and totally devours the whole, except the skin and bones. The Scarborough fishermen often take it in the robbed fish, on drawing up their lines. Linnæus attributes to it the property of turning water into glue.

N.

N, or n, the thirteenth letter of our alphabet; as a numeral stands for 900; with a dash over it, thus $\bar{N}$, for 900,000. N, or N°, stands for numero, *i. e.* in number; and N. B. for nota bene, note well, or observe well. Among the ancient Romans, N. denotes Nepos, Nonnius, &c. N. C. Nero Cæsar, or Nero Claudius; N. L. Non liquet; N. P. Notarius Publicus; and NBL. stands for nobilis.

NADIR, in astronomy, that point of the heavens which is diametrically opposite to the zenith, or point directly over our heads.

NAIAS, a genus of the monandria order, in the diœcia class of plants; and in the natural method ranking with those of which the order is doubtful. The male calyx is cylindrical and bifid; the corolla quadrifid; there is no filament, nor is there any female calyx or corolla; there is one pistil, and the capsule is ovate and unilocular. There is one species, an aquatic of the South of Europe.

NAIL. *unguis*. See Anatomy, and Horn.

NAILS, in building, &c. small spikes of iron, brass, &c. which being driven into wood, serve to bind several pieces together, or to fasten something upon them. The several sorts of nails are very numerous: as, 1. back and bottom nails, which are made with flat shanks to hold fast, and not open the wood. 2. Clamp-nails, for fastening the clamps in buildings, &c. 3. Clasp-nails, whose heads clasping and sticking into the wood, render the work smooth, so as to admit a plane over it. 4. Clench-nails, used by boat and barge-builders, and proper for any boarded buildings that are to be taken down; because they will drive without splitting the wood, and draw without breaking; of this there are many sorts. 5. Clout-nails, used for nailing on clouts to axle-trees. 6. Deck-nails, for fastening of decks in ships, doubling of shipping, and floors laid with planks. 7. Dog-nails, for fastening hinges on doors, &c. 8. Flat-points, much used in shipping, and proper where there is occasion to draw and hold fast, and no conveniency of clenching. 9. Jobent-nails, for nailing thin plates of iron to wood, as small hinges on cupboard-doors, &c. 10. Lead-nails, for nailing lead, leather, and canvas, to hard wood. 11. Port-nails, for nailing hinges to the ports of ships. 12. Pound-nails, which are four square, and are much used in Essex, Norfolk, and Suffolk, and scarcely any where else, except for pailing. 13. Ribbing-nails, principally used in ship-building, for fastening the ribs of ships in their places. 14. Rose-nails, which are drawn four-square in the shank, and commonly in a round tool, as all common twopenny nails are; in some countries all the larger sort of nails are made of this shape. 15. Rother-nails, which have a full head, and are chiefly used in fastening rother-irons to ships. 16. Round-head nails, for fastening on hinges, or for any other use where a neat head is required; these are of several sorts. 17. Scupper-nails, which have a broad head, and are used for fastening leather and canvas to wood. 18. Sharp nails; these have sharp points and flat shanks, and are much used, especially in the West Indies, for nailing soft wood. 19. Sheathing-nails, for fastening sheathing-boards to ships. 20. Square nails, which are used for hard wood, and nailing up wall-fruit. 21. Tacks, the smallest of which serve to fasten paper to wood, the middling for wool-cards, &c. and the larger for upholsterers and pumps.

Nails are said to be toughened when too brittle, by heating them in a fire-shovel, and putting some tallow or grease among them.

Nail, is also a measure of length, containing the sixteenth part of a yard.

NAIS, a genus of the vermes mollusca; the generic character is, body creeping, long, linear, pellucid, depressed: peduncles or feet with small bristles on each side. There are ten species: the digitata is found with single lateral bristles, tail laciniate, in stagnant waters, or the sandy sediment of rivers, with its head attached to the stalk of aquatic plants; it is about four lines long.

NAMA, a genus of the digynia order, in the pentandria class of plants; and in the natural method ranking under the 13th order, succulentæ. The calyx is pentaphyllous, the corolla quinquepartite, the capsule unilocular and bivalved. There is one species, an annual of Jamaica.

NANDINA, a genus of the class and order hexandria monogynia. The calyx is many-leaved, imbricate; corolla six-petalled. There is one species, a herb of Japan.

NAPÆA, a genus of the polyandria order, in the polyadelphia class of plants: and in the natural method ranking under the 37th order, columniferæ. The calyx is single and cylindric; the arilli coalited and monospermous. There are two species; both of them with perennial roots. Both of them are natives of Virginia and other parts of North America; from the bark of some of the Indian kinds a sort of fine hemp might be procured, capable of being woven into very strong cloth. They are easily propagated by seed, which will thrive in any situation.

NAPTHA, a name given to the most liquid bitumens; it is light, transparent, and very inflammable. There are several varieties, found chiefly in Italy, and particularly near Modena. Kempfer, however, says, that great quantities are collected in several parts of Persia: naturalists attribute the formation of the liquid bitumens to the decomposition of those that are solid, by the action of the subterraneous fires. Naptha is said to be the lightest, which the fire first disengages: naptha is very volatile, and so combustible, that it catches fire, if any thing

burning be brought near it. In Persia, this and the other bitumens are employed for the purpose of giving light in, lamps by means of wicks; they may be used also to give heat; for this purpose some naptha is poured on a few handfuls of earth, and kindled with paper, when it burns briskly, but diffuses a thick smoke, which adheres to every thing, and leaves a disagreeable smell. In India, the flame produced by it is worshipped, and the heat it emits is used for dressing victuals; and in some cases it has been successfully employed in paralytic diseases. See Bitumen.

NARCISSUS, a genus of the monogynia order, in the hexandria class of plants; and in the natural method ranking under the 9th order, spathaceæ. There are six petals; the nectarium is funnel-shaped and monophyllous; the stamina are within the nectarium. There are 15 species; the most remarkable are:

1. The bastard narcissus, or common yellow English daffodil, grows wild in great plenty in many of our woods and coppices, and under hedges, in several parts of England. Its commonness renders it of but little esteem with many; considered, however, as an early and elegant flower, of exceeding hardiness and easy culture, it merits a place in every garden, especially the double.

2. The bicolor, or two-coloured incomparable narcissus; the varieties are, common single-flowered, semi-double-flowered, with the interior petals some white, and some yellow, with sulphur-coloured flowers.

3. The poeticus, poetic daffodil, or common white narcissus, is well known. Of this there are varieties with purple-cupped flowers, yellow-cupped flowers, double-flowered; all of them with entire white petals. It is the ancient celebrated narcissus of the Greek and Roman poets, which they so greatly extol for its extreme beauty and fragrance.

4. The bulbocodium. From the large spreading nectarium of this species, which is three or four times longer than the petals, narrow at bottom, and widening gradually to the brim, so as to resemble the shape of some old-fashioned hoop petticoats, it obtained the name of hoop-petticoat narcissus.

5. The serotinus, or late-flowering small autumnal narcissus.

6. The tazetta, or multiflorous daffodil, commonly called polyanthus narcissus. The varieties of this are very numerous, consisting of about eight or nine principal sorts; each of which has many intermediate varieties, amounting in the whole to greatly above a hundred in the Dutch florists' catalogues, each variety distinguished by a name according to the fancy of the first raiser of it. They are all very pretty flowers, and make a charming appearance in the flower-borders, &c.; they are also finely adapted for blowing in glasses of water, or in pots, to ornament rooms in winter.

7. The jonquila, or jonquil, sometimes called rush-leaved daffodil. The varieties are, jonquil minor with single flowers, jonquil major with single flowers, starry-flowered, yellow and white flowered, white-flowered, semi-double-flowered, double-flowered, and large double inodorous jonquil; all of them multiflorous, the single in particular; but sometimes the doubles produce only two or three flowers from a spatha, and the singles commonly six or eight. All the sorts have so fine a shape, so soft a colour, and so sweet a scent, that they are among the most agreeable spring-flowers.

8. The calathinus, or multiflorous yellow narcissus.

9. The odorus, odoriferous, or sweet-cented starry-yellow narcissus.

10. The triandrus, or triandrous rushleaved white narcissus.

11. The trilobus, or trilobate yellow narcissus.

12. The minor, or yellow winter daffodil.

NARCOTICS, in medicine, soporiferous medicines, which excite a stupefaction. See the next article.

NARCOTIC Principle. It has been long known that the milky juices which exude from certain plants, as the poppy, lettuce, &c. and the infusions of others, as of the leaves of the digitalis purpurea, have the property of exciting sleep, or, if taken in doses large enough, of inducing a state resembling apoplexy, and terminating in death. How far these plants owe these properties to certain common principles which they possess, is not known, though it is exceedingly probable that they do. But as a peculiar substance has been detected in opium, the most noted of the narcotic preparations, which possesses narcotic properties in perfection, we are warranted, till further experiments elucidate the subject, to consider it as the narcotic principle, or at least as one species of the substances belonging to this genus.

Opium is obtained from the papaver album, or white poppy, a plant which is cultivated in great abundance in India and the East. The poppies are planted in a fertile soil, and well watered. After the flowering is over, and the seed-capsules have attained nearly their full size, a longitudinal incision is made in them about sun-set for three or four evenings in succession. From these incisions there flows a milky juice, which soon concretes, and is scraped off the plant and wrought into cakes. In this state it is brought to Europe.

Opium thus prepared is a tough brown substance, has a peculiar smell, and a nauseous bitter acrid taste. It becomes softer when held in the warm hand, and burns very readily and strongly. It is a very compound substance, containing sulphat of lime, sulphat of potass, an oil, a resinous body, an extractive matter, gluten, mucilage, &c. besides the peculiar narcotic principle to which probable it owes its virtues as a narcotic.

When water is digested upon opium, a considerable portion of it is dissolved, the water taking up several of its constituents. When this solution is evaporated to the consistence of a syrup, a gritty precipitate begins to appear, which is considerably increased by diluting the liquid with water. It consists chiefly of three ingredients; namely, resin, oxygenized attractive, and the peculiar narcotic principle which is crystallized. When alcohol is digested on this precipitate, the resin and narcotic substances are taken up, while the oxygenized extractive remains behind. The narcotic principle falls down in crystals as the solution cools, still however coloured with resin. But it may be obtained tolerably pure by repeated solutions and crystallizations.

Water is incapable of dissolving the whole of opium. What remains behind still contains a considerable portion of narcotic principle. When alcohol is digested on this residuum, it acquires a deep red colour; and deposits, on cooling, crystals of narcotic principle, coloured by re-

sin, which may be purified by repeated crystallizations. The narcotic principle obtained by either of these methods possesses the following properties:

Its colour is white. It chrystallizes in rectangular prisms with rhomboidal bases. It has neither taste nor smell.

It is insoluble in cold water, soluble in about 400 parts of boiling water, but precipitates again as the solution cools. The solution in boiling water does not affect vegetable blues.

It is soluble in 24 parts of boiling alcohol and 100 parts of cold alcohol. When water is mixed with the solution, the narcotic principle precipitates in the state of a white powder.

Hot ether dissolves it, but lets it fall on cooling.]

When heated in a spoon it melts like wax. When distilled it froths, and emits white vapours, which condense into a yellow oil. Some water and carbonat of ammonia pass into the receiver; and at last carbonic acid gas, ammonia, and carbureted hydrogen gas, are disengaged. There remains a bulky coal, which yields traces of potass. The oil obtained by this process is viscid, and has a peculiar aromatic smell and an acrid taste.

It is very soluble in all acids. Alkalies throw it down from these solutions in the state of a white powder.

Alkalies render it rather more soluble in water. When they are saturated with acids, the narcotic principle falls down in the state of a white powder, which is redissolved by adding an excess of acid.

Volatile oils, while hot, dissolve it; but, on cooling, they let it fall in an oleaginous state at first, but it gradually crystallizes.

When treated with nitric acid, it becomes red and dissolves; much oxalic acid is formed, and a bitter substance remains behind.

When potass is added to the aqueous solution of opium, the narcotic principle is thrown down; but it retains a portion of the potass.

Its solubility in water and alcohol, when immediately extracted from opium, seems to be owing to the presence of resin and extractive matter, both of which render it soluble.

It possesses the properties of opium in perfection. Derosne tried it upon several dogs, and found it more powerful than opium. Its bad effects were counteracted by causing the animals to swallow vinegar. This substance is known to be of equal service in counteracting the effects of opium. Derosne supposes that the efficacy of vinegar may be owing to the readiness with which it dissolves the narcotic principle.

* Many other substances beside opium possesses narcotic virtues; but hitherto they have not been examined by chemists with much attention. The most remarkable are the following:

1. The lactuca virosa, and the sativa or garden-lettuce, and indeed all the lactucas, yield a milky juice, which, when inspissated, has very much the appearance of opium, and possesses the same properties. Indeed Dr. Coxe of Philadelphia affirms, that as good opium may be obtained from the garden-lettuce as from the poppy. The milky juice is obtained by incisions at the time when the lettuce is running to seed. The resemblance between the inspissated juice of the lactuca viroso and opium is striking.

2. The leaves of the atropo belladonna, or deadly nightshade, and indeed the whole plant, are remarkably narcotic; and when taken in too great doses produce blindness, convulsions, coma, and death.

3. The leaves of the digitalis purpurea, or fox-glove, are still more powerful if possible. They lower the pulse in a remarkable degree, and, like several other very poisonous narcotics, promote the discharge of urine.

4. Hyoscyamus, niger or henbane.

5. Conium maculatum, or hemlock.

6. Datura stramonium.

7. Ledum palustre.

To these may perhaps be added the prunus laurocerasus, and the leaves of nicotiana tabacum or tobacco. The list, indeed, might be easily increased; almost all the plants belonging to the natural order of luridæ possessing narcotic properties; but as we are completely ignorant of the chemical properties of these plants, it is unnecessary to be more particular.

Narcotic salt. See Boracic acid.

NARDUS, a genus of the monogynia order, in triandria class of plants; and in the natural method ranking under the 4th order, gramina. There is no calyx; the corolla is bivalved. There are three species. This plant was highly valued by the ancients both as an article of luxury and medicine. The unguentum nardinum was used at baths and feasts as a favourite perfume. Its value is evident from that passage of scripture, where our Saviour's head was anointed with a box of it, with which Judas found fault. From a passage in Horace it appears that this ointment was so valuable among the Romans, that as much as could be contained in a small box of precious stone was considered as a sort of equivalent for a large vessel of wine, and a proper quota for a guest to contribute at an entertainment. The plant had a great character among the ancients as a medicine, both internally taken and externally applied. Its sensible qualities, indeed, promise to be of considerable efficacy in some cases, as it has a pungency of taste superior to contrayerva, and little inferior to serpentaria.

NATIONAL DEBT, the sum which is owing by a government to individuals who have advanced money for public purposes, either in anticipation of the produce of particular branches of the revenue, or on credit of the general power which the government possesses of levying the sums necessary to pay interest for the money borrowed, or to repay the principal. The practice of borrowing money on account of the state has been found so convenient, that almost every nation of modern Europe is encumbered with a considerable debt: the different manner of conducting hostilities in ancient and modern times has perhaps rendered this practice absolutely necessary, as the vast expenses with which wars are now attended could not possibly be defrayed during the time of their continuance, without producing the greatest distress, or perhaps absolute ruin, to the countries engaged in them. In ancient times wars were not only shorter in their duration, but were conducted on principles which rendered great pecuniary supplies less necessary than at present; the whole contest was a scene of plunder and devastation, the persons and property of the enemy were

at the entire disposal of the conqueror, and the greater part of the plunder was accounted for to the public. The arms made use of were much less expensive than those of modern warfare, and the extent of naval operations, the great source of national expenditure in modern times, was comparatively trifling. Sir J. Sinclair has justly observed, that had the rage of equipping numerous fleets, and building ships of great magnitude and dimensions, never existed, hardly any state in Europe would have been at this time in debt.

The principal advantages arising from national debts, and the system of credit on which they are founded, are, 1. The resource they afford in great emergencies, which gives a greater permanency to states, which in former times, for want of such occasional resources, were more liable to internal derangements and to foreign subjugation. 2. The equalization of taxes. If the supplies were raised within the year, and the expenses of war were considerable, every individual would be obliged, in consequence of the additional weight of his contributions, greatly to curtail his expenses; and the employment of the poor, and the consumption of the rich, would be considerably diminished; whereas, when taxes are nearly equal, in time of peace and war, the value of every species of property, of industry, and the circulation of wealth, are maintained on as regular, steady, and uniform a footing, as the uncertainty and instability of human affairs will admit. 3. They retain money in the country, which would otherwise be sent out of it; public debts have more influence in this respect than all the laws against the exportation of specie that ever were made. 4. They promote circulation. The taxes which they occasion on the property of the rich, and the encouragement they hold out to the avaricious, prevent the accumulation of private hoards, and bring the whole money and personal property of a country into employment. 5. They attach the people to the government; for every individual creditor is led by his own interest to support the authority on the prosperity and existence of which the security of his property depends. The extent of this influence is so well understood, that it is not probable the government of any country where a public debt has once existed, will ever permit it to be wholly paid off. 6. They encourage industry and the acquirement of property, by the facility with which individuals can lay out the surplus of their profits, without the risk of commercial bankruptcies, or the unavoidable expenses and small advantage which landed estates yield, and receive interest on their capital with certainty and regularity.

The disadvantages attending the system of incurring national debts, are, 1. The facility of carrying on war being much increased; while large sums can be easily borrowed, it may frequently cause wars to be protracted, which would have been much sooner brought to a termination, had the governments engaged in them experienced the difficulty of defraying the whole expense by taxation. 2. The value of the property of those who have lent their money to the state, depending on the public tranquillity, inclines them to support indiscriminately the measures of the government, whatever may be their tendency: they are interested both to preach and practice apathy under every invasion of the constitution of their country. 3. The increase of taxes to pay the interest of the debt, produces an increase in the price of all the necessaries of life, and renders it difficult for the manufacturers of a state in which this system has been carried to a great height, to maintain a successful competition with the subjects of other powers, who may be in a less embarrassed situation. 4. When a nation is encumbered with debts, a pernicious spirit of gambling is encouraged: stock-jobbing, with all its train of evil consequences, necessarily arises; and a moneyed interest is erected, the sole employment of which is that of drawing every possible advantage from the wants of individuals, or the necessities of the public. 5. Public debts have a very material influence on the distribution of property. Every new loan must be procured from persons already possessing considerable wealth, and such persons will not lend their money without the expectation of making a profit by it; the increase of the debt is, therefore, to them a source of increasing wealth, to which their share of the additional taxes attendant upon it bears but a small proportion; and if the government possesses no revenue but what is drawn from the people, whatever it pays to one description of men must be drawn principally from others: thus the additional income acquired by moneyed men, by taking advantage of the necessities of the state, is, in fact, a portion of the income of their less affluent fellow-citizens, which is transferred to them through the medium of the government, and which, in a much greater proportion than it increases their wealth, must render those poorer from whom it is drawn.

The practice of incurring national debts on extraordinary occasions had been resorted to in other countries long before it was adopted in England. The Italian republics seem to have begun it; Genoa and Venice had both considerable debts. Spain was deeply in debt before the end of the 16th century, about a hundred years before England owed a shilling. In France the funding system was introduced about the year 1678; and previously to the revolution, the debt of that country was 142 millions sterling; two-fifths of which consisted of life-annuities, which in this estimate are taken at eleven years purchase.

The national debt of Great Britain commenceneed in the reign of William III. The war which began in 1689 being very expensive, and the grants of parliament not supplying money so fast as it was wanted, the expedient of mortgaging part of the public revenue was adopted. At first the produce of particular taxes was assigned for repayment of the principal and interest of the money borrowed; large sums were also raised on life-annuities, and annuities for terms of years; and the funds established for payment of these debts being generally inadequate to the charge upon them, occasioned great deficiencies, which, at the conclusion of the war, amounted to 5,160,459*l.* 14*s.* 9¼*d.* and were charged on the continuation of various duties which had been granted for short terms. The total amount of the funded and unfunded debts in the year 1697, was 19,950,945*l.* 19*s.* 8¾*d.* The frequent anticipation of the different funds, and their general deficiency from the diminution of the revenue, in consequence of which the interest due upon money lent to government was often long in arrear, reduced public credit at this period to a very low ebb, and ren-

dered persons who had money very reluctant in advancing it to the government, though paid what would now be called an exorbitant interest: the accumulation of the public debts caused serious apprehensions among people of property of all descriptions.

The great expesne of the war during the reign of queen Anne was chiefly defrayed by the sale of annuities for different terms, but mostly for 99 years; and money was not only borrowed to pay the interest of loans, but often to pay the interest of that interest; or, what is much the same thing, the arrears of interest were converted into principal, by which means, and from great mismanagement of the public finances, the debt rapidly increased, and on the 31st December 1716, amounted to 48,364,501*l.* 8*s.* 4*d.* This amount was considered, in the language of the king and parliament, as an "insupportable weight;" and the house of commons expressed their determination to apply themselves, with all possible diligence and attention, to the great and necessary work of reducing by degrees this heavy burthen, as the most effectual means of preserving to the public funds a real and certain security.

The current rate of interest having lowered considerably, a plan was adopted for reducing the rate of interest payable on such part of the public debts as carried 6 per cent. interest, which causing a surplus in the funds appropriated to the payment of the interest, the overplus remaining, after satisfying the charges upon the respective funds, was formed into a separate fund, under the title of the sinking fund, for the express purpose of discharging such national debts as were incurred before December 1716, and "for no other use, intent, or purpose, whatsoever." This arrangement was well calculated for effecting a gradual reduction of the amount of the debt, and gave a new confidence to the public creditors, from a persuasion that the provisions made would prevent the inconveniences which had formerly arisen from the interest of particular debts being frequently long in arrear; and that instead of the depression of the current value of their securities, which generally attends the increase of public debts, this value would increase in proportion to the progress of redemption. The public had also a distant hope at least of being relieved from some of the many taxes which it had been necessary to impose for paying the interest of the debt, the pernicious effects of which, both on the foreign trade and the internal state of the country, began to be sensibly felt.

The expectations entertained from the sinking fund were, however, soon disappointed; as the period of its strict application to the purpose for which it was established did not exceed 10 or 11 years. The famous South Sea scheme was likewise to have furnished a considerable sum to be employed in the reduction of the public debts; instead of which it increased their amount by an addition to the capital of 3,034,769*l.* 11*s.* 11*d.*, while the annual charge was rather augmented than diminished by the allowance for management on the increased capital: a further reduction of a part of the interest was however secured by this transaction.

In 1727 the interest payable on 29,962,979*l.* 12*s.* $9\frac{1}{4}$*d.* South Sea stock and annuities, and on 7,775,027*l.* 17*s.* $7\frac{1}{2}$*d.* due to the Bank, was reduced from 5 to 4 per cent, which produced such an important augmentation of the sinking fund, that had it been faithfully applied to the purpose for which it was intended, and received no other increase than what would have arisen from a judicious application of it, the national debt would at this time have been wholly annihilated. During the reign of George I. the fund continued to be appropriated to the purposes for which it was formed: little progress, however, was made in discharging the public debts; for at the same instant that old incumbrances were thus paid off, new debts were contracted; so that at the end of the year 1727, the total of the funded debt amounted to 51,258,939*l.* 4*s.* $2\frac{1}{4}$., of which it must be remembered that upwards of three millions arose from the additional capital created by the South Sea company's subscription.

The whole sum paid off by the sinking fund from its establishment to the year 1739, was only 8,328,354*l.* 17*s.* 11*d.*; and the total amount of the debt at this period 46,954,623*l.* 3*s.* $4\frac{1}{2}$d.

The war with Spain and France, which began in this year, increased the debt to 78,293,313*l.* 1*s.* 10*sd*$\frac{1}{3}$., the interest on which amounted to 3,061,004*l.* 11*s.* $1\frac{3}{4}$*d.* per ann.

The interest of money, which had risen during the war to upwards of 4 per cent. fell, when the cessation of hostilities terminated the loans of government, to 3 per cent.; and the administration seized the moment of increased prosperity to propose another important reduction of interest. Towards the end of 1749, 3 per cent. stock had been for some months above par: an act was therefore passed by which the interest was reduced on all the public debts redeemable by law, which then carried 4 per cent. interest, forming together a capital of 57,702,475*l.* 6*s.* $4\frac{1}{2}$*d.* The proprietors, on signifying their consent to the reduction, were to have 4 per cent. interest to the 25th December following, thence $3\frac{1}{2}$ per cent. till 25 December, 1757, and afterwards 3 per cent. per annum. Upwards of three millions remained unsubscribed, which was therefore paid off, by money borrowed at 3 per cent., and thus a saving of 612,735*l.* per annum was effected, which ought to have contributed materially to the reduction of the debt. Little progress, however, was made in diminishing the capital of the debt; and at the commencement of the war in 1755 it amounted to 74,980,886*l.* 8*s.* $2\frac{1}{4}$*d.*

The great expenses of the war rendered the loans of greater magnitude than had ever before been raised, and the debts incurred were somewhat increased by the practice of entitling the persons lending the money to a greater capital than the sum actually advanced; so that at the end of the war, including the loan of 1763, they amounted to 141,691,313*l.* 13*s.* 4*d.*, and the annual interest to 4,706,734*l.* 0*s.* 11*d.*

During the succeeding 12 years of peace, little was done in reality towards diminishing the amount of the debt: for although in each year from 1765 to 1775, some small portion of the funded debt was paid off, the whole amounted to only 11,983,553*l.* being a less amount than had sometimes been borrowed in one year of war: and the debt was far from being diminished even this amount, as during the same period a new debt of 5,052,500*l.* was contracted, by borrowing money on 3 per cent. stock, in order to redeem 4 per cents.

The American war was entered into with a fu... debt of 132,343,051*l.*, including an estimated val.

the long annuities and exchequer annuities, and an unfunded debt of about 3,600,000*l.*, making together 135,943,051*l.* the interest on which amounted to 4,476,821*l.* per annum. The expenses of this war greatly exceeded those which had preceded it; and the increase of the debt was much greater than had ever been incurred by any country in the same space of time. The following statements will show the extent of the sums borrowed, and the additions thus made to the annual burthen of the country:

	Money bor.	Debt created.	Interest.
1776	2,000,000	2,150,000	64,500
1777	5,000,000	5,000,000	225,000
1778	6,000,000	6,000,000	330,000
1779	7,000,000	7,000,000	472,500
1780	12,000,000	12,000,000	697,500
1781	12,000,000	21,000,000	660,000
1782	13,500,000	20,250,000	793,125
1783	12,000,000	15,000,000	560,000
1784	6,000,000	9,000,000	316,500
	*L*75,500,000	97,400,000	4,119,125

From which it appears that a nominal capital of 21,900,000*l.* was added to the sum of 75,500,000*l.* actually borrowed, and that the interest on the whole amounted to 5*l.* 9*s.* 1*d.* per cent. on which the perpetual interest was equal to 4*l.* 6*s.* per cent. on the whole sum. In addition to the above sums, a very considerable amount of navy debt was funded after the conclusion of the war, which being properly part of the expenses of it, the total debt incurred by the American war may be stated as follows:

	Debt created.	Interest.
In 3 per cents.	64,648,000	1,939,440
4 per cents.	32,750,000	1,310,000
5 per cents.	17,869,992	893,499
Terminable annuities		869,623
	*L*115,267,992	5,012,562

The whole amount of the funded and unfunded debts, including a valuation of the terminable annuities, was on the 5th Jan. 1786, 268,100,379*l.* 18*s.* 8*d.*, and the amount of the annual interest 9,512,232*l.* 7*s.* 9*d.*

The magnitude of the public debt, and the consequent low price of the funds, appear at this period to have engaged the serious attention of the government; in consequence of which some new taxes were imposed, in order to raise a surplus of revenue, as the foundation of a plan for establishing a new sinking fund. In order to ascertain what portion of the revenue might be appropriated to this purpose, a select committee of the house of commons was appointed to examine and state of the accounts presented to the house relating to the public income and expenditure, and to report what might be expected to be the annual amount of the income and expenditure in future. On the 21st March, 1786, the committee made their report; and conceiving that the circumstances of the times rendered any average drawn from the amount of the revenue in former periods in a great degree inapplicable to the situation of the country, they formed an account of the public receipt and expenditure to Michaelmas 1785, and to January 1786, from which it appeared, that at the former period there was a surplus of 901,001*l.*, and at the latter a surplus of 919,290*l.* As it was evident that a fund of less than one million per annum would be very inadequate to the purpose for which it was designed, new taxes were imposed for raising the surplus revenue to this sum; and in order the more effectually to prevent ministers from diverting it to any other purpose, the mode was adopted which had been frequently suggested, of vesting the annual sum in the hands of commissioners: some other judicious regulations were also established by the act passed for this purpose. See Sinking Fund.

In the year 1789, it was found necessary to borrow 1,002,140*l.* on a tontine scheme, and 187,000*l.* to replace the like sum which had been issued out of the civil list revenue, as a loan to the prince of Orange: the latter was raised on annuities for $18\frac{3}{4}$ years. The total amount of the public debt in the year 1792, being the year previous to the war with the French republic, was, according to the official account, 238,231,248*l.*; but including the value of the terminable annuities, and the amount of the unfunded debt, the total was 268,267,272*l.* 1*s.* 7*d.*, the annual interest and charges of management on which amounted to 9,752,673*l.* 14*s.* 8*d.* From this amount, however, a deduction is to be made of the stock which had been redeemed by the operation of the sinking fund. With this formidable burthen on the property and industry of the country, a war was entered into, which from the enormous expenditure attending it, increased the amount of the national debt in a degree beyond all former precedent or conjecture. The loan of the year 1793 was raised wholly on 3 per cent. stock, and those of the subsequent years being also raised chiefly on this description of stock, an unnecessary addition has been made to the capital of the debt, and the charge for management has been considerably augmented, as the allowance to the bank on this account is computed on the capital created. In the third year of the war the amount of the loan was considerably greater than had ever before been borrowed in one year; but still larger sums were raised in some of the succeeding years. The natural consequence of such a rapid accumulation of debt was a great depreciation of the current prices of the public funds, so that the government was obliged to allow a very high interest for the money borrowed; and towards the end of the year 1797, many persons seemed to entertain an apprehension that the funding system had been extended nearly to its limits; in consequence of this opinion, various expedients were successively tried for raising a considerable part of the war expenditure within the year; none of these projects fully succeeded, but they certainly rendered the sums which it was necessary to borrow, somewhat less in amount than they must otherwise have been; still, however, they were of unprecedented magnitude, and in 1802, after the conclusion of the war, it was still found necessary to borrow twenty-five millions more, to make good expenses of the war remaining unprovided for. The total amount of the national debt at Midsummer 1802, including the stock created by the imperial loans, and estimating the unfunded debt at 15,500,000*l.* was 619,303,027*l.* 9*s.* 6*d.*, the annual charge of which for interest and management amounted to 21,557,728*l.* 15*s.* 6*d.* From this amount is to be deducted the stock bought up by the commissioners, and transferred to them for redemption of land-tax.

PROGRESS OF THE NATIONAL DEBT, FROM ITS COMMENCEMENT TO MIDSUMMER 1802.

	Capital.	Interest.
National Debt at the Revolution, 1688 - -	L. 664,363	39,855
Increase during the reign of William IIId.	15,730,439	1,271,087
Amount at the accession of Queen Anne - -	16,394,702	1,310,942
Increase during the reign of Queen Anne -	31,969,799	1,841,582
Amount at establishment of Sinking Fund, 1716	48,364,501	3,152,524
Increase during the reign of Geo. I. - -	4,654,654	
Decrease of annual charge - - - -		941,958
Amount at the accession of Geo. IId. - -	53,019,155	2,210,566
Decrease during the Peace - - - -	6,064,532	245,541
Amount at commencement of the War, 1739 -	46,954,623	1,964,025
Increase during the War - - - -	31,338,689	1,096,979
Amount at the end of the War in 1748 - -	78,293,312	3,061,004
Decrease during the Peace - - -	3,312,426	389,364
Amount at the commencement of the War 1755 -	74,980,886	2,671,640
Increase during the War - - - -	66,710,427	2,035,094
Amount at the end of the War, 1762 - - -	141,691,313	4,706,734
Decrease during the Peace - - -	5,748,262	229,913
Amount at the commencement of the American War	135,943,051	4,476,821
Increase during the War - - -	132,157,328	5,035,411
Amount at the conclusion of the American War	268,100,379	9,512,232
Increase in the year 1789 - - -	1,189,140	56,863
Amount in 1789 - - - - - - -	269,289,519	9,569,095
Redeemed during Peace - - - - -	9,441,850	283,255
Amount at the commencement of the War, 1793	259,847,669	9,285,840
Increase during the War - - - - -	350,013,508	11,988,633
	609,861,177	21,274,473
Redeemed during the War - - -	69,243,336	2,089,220
Amount at conclusion of the War in 1802 -	540,617,841	19,185,253

Since the period at which the above statement terminates, another war has been entered into, which has already added many millions to the public debt; but as the sum to which it may be increased is beyond the reach even of probable estimate, we can only give the following statement of the total amount of the debt on the 5th January 1806, which will also show the different descriptions of stock and annuities of which it consists:

NATIONAL DEBT OF GREAT BRITAIN.

	Capital.			Interest and Management.		
5 per Cent. Consolidated Annuities -	L. 41,389,136	8	4	L. 2,088,081	18	7
5 per Cent. Annuities. 1797 and 1802 -	9,088,902	16	3	458,535	2	10
4 per Cent. Consolidated Annuities - -	49,725,084	17	2	2,011,379	13	7
3 per Cent. Reduced Annuities - -	137,246,269	3	7	4,179,148	17	2
3 per Cent. Consolidated Annuities -	376,707,982	2	0¼	11,470,758	0	3
3 per Cent. Deferred Annuities - -	1,740,625	0	0	——		
3 per Cent. Annuities, 1726 - -	1,000,000	0	0	30,450	0	0
Bank Stock - - - - - -	11,686,800	0	0	356,502	3	5
South Sea Stock - - - - -	3,662,784	8	6			
Old South Sea Annuities - - - -	11,907,470	2	7	735,974	13	11
New South Sea Annuities - - - -	8,494,830	2	10			

South Sea Annuities, 1751	1,919,600	0	0	58,325	15	6
Imperial 3 per Cent. Annuities	7,502,633	6	8	228,455	3	8
Value of the Long Annuities	19,969,799	12	6	1,075,669	4	11
Do. of the Short Annuities	786,599	5	1	423,039	5	9
Do. of Imperial Annuities	2,184,694	7	9	232,587	10	0
Do. of the Life Annuities	403,779	9	6	67,296	11	7
Annuities on Lives, with Survivorship, 1765	18,000	0	0	540	0	0
Tontine Annuities, 1789	280,452	18	0	20,032	7	0
Value of Exchequer Annuities	23,668	0	0	23,668	0	0
	685,739,112	0	9¼	23,460,444	8	2
Redeemed by Sinking Fund	104,701,999	0	0	3,170,073	19	4
	581,037,113	0	9¼	20,290,370	8	10
Transferred for Land Tax redeemed	22,000,000	0	0	660,000	0	0
Total Funded Debt	559,037,113	0	9¼	19,630,370	8	10
Navy, Victualling, and Transport Debt	5,500,000	0	0			
Army, Barracks, Ordnance, &c.	3,000,000	0	0	681,000	0	0
Treasury Bills, &c.	1,200,000	0	0			
Exchequer Bills	13,000,000	0	0			
Total of the Nat. Debt and the ann. int. thereon,	581,737,113	0	9¼	20,311,370	8	10

For the comparative value of the different funds, and the mode of transacting business therein, see Public Funds.

NATRUM. See Soda.

NATIVITY, in old law-books, signifies villainage or servitude.

NATURAL HISTORY. The object of this branch of science may be divided into two heads; the first teaches us the characteristics, or distinctive marks, of each individual object, whether animal, vegetable, or mineral; the second makes us acquainted with all its peculiarities, as to its habits, its qualities, and its uses. To assist in attaining the first, it is necessary to adopt some system of classification, in which individuals that agree in particular points may be arranged together. In this work we have adopted the Linnæan system, as the most simple and perfect that has been presented to the public.

A knowledge of the second head is only gained by a patient investigation of each particular object; for this we refer the reader to the several genera described in these volumes, under which we have endeavoured to give a brief account of all the interesting and material facts.

The study of natural history consists in the collection, arrangement, and exhibition, of the various productions of the earth. These are divided into the three grand kingdoms of nature, the boundaries of which meet together in the zoophytes. See Zoophytes.

Minerals inhabit the interior parts of the earth, in rude and shapeless masses. They are bodies concrete without life and sensation. See Mineralogy.

Vegetables clothe the surface with verdure, imbibe nourishment through bibulous roots, breathe by leaves, and continue their kind by the dispersion of seed within prescribed limits. They are organized bodies, and have life and not sensation. See Botany.

Animals adorn the exterior parts of the earth, respire and generate eggs; are impelled to action by hunger, affections, and pain; and by preying on other animals and vegetables, restrain within proper bounds and proportions the numbers of both. They have organized bodies, and have life, sensation, and the power of locomotion.

Man, the governor and subjugator of all other beings, is, by his wisdom alone, able to form just conclusions from such things as present themselves to his senses, which consist of natural bodies. Hence the first step of wisdom is to know these bodies; and to be able, by marks imprinted on them by the God of nature, to distinguish them from each other, and to affix to every object its proper name. These are the elements of this science; this is the great alphabet of nature: for if the name is lost, the knowledge of the object is lost also.

The method adopted in natural history, indicates that every body may, by inspection, be known by its peculiar name, and this points out whatever the industry of man has been able to discover concerning it; so that, amidst the greatest apparent confusion, the greatest order is visible.

The Linnæan system is divided into five branches, each subordinate to the other: these are, class, order, genus, species, and variety, with their names and characters. In this arrangement, the classes and order are arbitrary, the genera and species are natural.

Of the three grand divisions above referred to, the animal kingdom ranks highest in comparative estimation, the next the vegetable, and last is the mineral kingdom.

To the vegetable and mineral kingdoms, we have already referred under the distinct heads Botany and Mineralogy: with regard to the animal kingdom, we observe that,

Animals enjoy sensation by means of a living organization, animated by a medullary substance; perception by nerves; and motion by the exertion of the will. They have members for the different purposes of life; organs for their different senses; and faculties or powers for the application of their different perceptions. They all originate from an egg. Their external and internal structure, habits, instincts, and various relations to each other, will be found under the different genera. See also Comparative Anatomy.

The division of animals is into six classes, formed from their internal structure.

1. Mammalia	Heart with two auricles and two ventricles: blood warm and red.	viviparous
2. Birds		oviparous
3. Amphibia	Heart with one auricle and one ventricle: blood cold and red.	lungs voluntary
4. Fishes		
5. Insects	Heart with one auricle, ventricle 0: sanies cold and white.	have antennæ
6. Vermes		tentacula.

The following is an abstract of Linnæus's Systema Naturæ, by Gmelin.

CLASS I. MAMMALIA.

Order.	Genera.	Species.
Primates	4	88
Bruta	7	25
Feræ	10	186
Glires	10	129
Pecora	8	90
Belluæ	4	25
Cete	4	14
7	47	557

CLASS II. AVES.

Order.	Genera.	Species.
Accipitres	4	271
Picæ	26	663
Anseres	13	314
Grallæ	20	326
Gallinæ	10	129
Passeres	17	983
6	87	2686

CLASS III. AMPHIBIA.

Order.	Genera.	Species.
Reptilia	4	147
Serpentes	6	219
2	10	366

CLASS IV. PISCES.

Order.	Genera.	Species.
Apodes	10	37
Jugulares	6	52
Thoracici	19	452
Abdominales	16	202
Branchiostegi	10	81
Chondropterygii	5	65
6	66	889

CLASS V. INSECTÆ.

Order.	Genera.	Species.
Coleoptera	55	4048
Hemiptera	14	1464
Lepidoptera	3	2600
Neuroptera	7	174
Hymenoptera	25	1239
Diptera	12	692
Aptera	15	679
7	121	10896

CLASS VI. VERMES.

Order.	Genera.	Species.
Intestina	21	384
Mollusca	31	538
Testacea	36	2525
Zoophita	15	498
Infusioria	15	191
5	118	4036.

NATURAL PHILOSOPHY, that which considers the powers and properties of natural bodies, and their actions on one another.

Our knowledge of nature being now found to result entirely from well-conducted experiments, the term natural philosophy has been laterally confounded with that of experimental philosophy, and indeed they seem nearly to mean the same thing. See EXPERIMENTAL PHILOSOPHY. Natural philosophy is, however, obviously rather a system or aggregate of several branches of knowledge, than a simple and uniform science. These branches, therefore, it was necessary to treat of under separate articles, to which we must content ourselves with referring upon this occasion, arranging them in the order in which we think they may be studied with most advantage, viz. ATTRACTION, GRAVITATION, and GRAVITY, MAGNETISM, MOTION, MECHANICS, PNEUMATICS, HYDROSTATICS, HYDRAULICS, ELECTRICITY, GALVANISM, OPTICS, ASTRONOMY; to which we may add CHEMISTRY and MINERALOGY.

NATURALIZATION, is when an alien-born is made the king's natural subject.

Hereby an alien is put in the same state as if he had been born in the king's liegeance, except only that he is incapable of being a member of the privy council or parliament, and of holding any office or grant. No bill for a naturalization can be received in either house of parliament, without such disabling clause in it; nor without a clause disabling the person from obtaining any immunity in trade thereby, in any foreign country, unless he shall have resided in Britain seven years after the commencement of the session in which he is naturalized. Neither can any person be naturalized, or restored in blood, unless he has received the sacrament within one month before bringing in of the bill, and unless he also takes the oaths of allegiance and supremacy in the presence of the parliament. 1 Black. 374. See ALIEN.

NAVAL STORES comprehend all those particulars made use of, not only in the royal navy, but in every other kind of navigation; as timber for shipping, pitch, tar, hemp, cordage, sail-cloth, gunpowder, ordnance and fire-arms of every sort, ship-chandlery wares, &c.

NAUCLÆA, a genus of the pentandria monogynia class and order. The corolla is funnel-form; seed one, inferior, two-celled; receptacle, common globular. There are four species, trees of the East Indies, &c.

NAVIGATON, the art of conducting a ship from one port to another. The main end of all practical navigation is, to conduct a ship in safety to her destined port;

and for this purpose it is of the utmost consequence to know in what particular part of the surface of the globe she is at any particular time. This can only be done by having an accurate map of the sea-coasts of all the countries of the world, and, by tracing out the ship's progress along the map, to know at what time she approaches the desired haven, or how she is to direct her course in order to reach it. It it therefore a matter of great importance for navigators to be furnished with maps, or charts, as they are called, not only very accurate in themselves, but such as are capable of having the ship's course easily traced upon them, without the trouble of laborious calculations, which are apt to create mistakes. The navigator should have a perfect knowledge of the figure and motion of the earth; the varions real and imaginary lines upon it, so as to be able to ascertain the distance and situation of places with respect to one another. He should also be acquainted with the several instruments employed in measuring the ship's way; such as the log, half-minute glass; quadrant to take the altitude of the sun and stars; compass to represent the sensible horizon; and azimuth compass to take the azimuth and amplitude of the sun, in order to know the variation of the magnetic needle. He should have an accurate knowledge of maps and charts of the lands and seas, together with the depth of water, the times and setting in of the tides upon the coasts that he may have occasion to visit; also the currents; of the mould and trim of the ship, and the sail she bears, that so a due allowance may be made for lee-way. By the help of these, he may at all times know the place the ship is in, which way he must steer, and how far he has to run to gain his intended port.

The names of the two great divisions of navigation are taken merely from the kind of charts made use of. Plane sailing is that in which the plane chart is made use of; and Mercator's sailing, or globular sailing, is that in which Mercator's chart is used. In both these methods, it is easy to find the ship's place with as great exactness as the chart will allow, either by the solution of a case in plane trigonometry, or by geometrical construction.

Of plane sailing. As a necessary preliminary to our understanding this method of navigation, we shall here give the construction of the plane chart.

1. This chart supposes the earth to be a plane, and the meridians parallel to one another; and likewise the parallels of latitude at equal distances from one another, as they really are upon the globe. Though this method is in itself evidently false; yet, in a short rnn, and especially near the equator, an account of the ship's way may be kept by it tolerably well.

Having determined the limits of the chart, that is, how many degrees of latitude and longitude, or meridional distance (they being in this chart the same), it is to contain: suppose from the lat. of 20° N. to the lat. of 71° N., and from the longitude of London in 0 deg. to the long. of 50° W.; then choose a scale of equal parts, by which the chart may be contained within the size of a sheet of paper on which it is intended to be drawn.

Make a parallelogram ABCD (Plate XCIII. Navigation, fig. 1), the length of which AB from north to south shall contain 51 degrees, the difference of latitude between the limits of 20° and 71°; and the breadth AD from east to west shall contain the proposed 50 degrees of longitude, the degrees being taken from the said scale, and this parallelogram will be the boundaries of the chart.

About the boundaries of the chart make scales containing the degrees, halves, and quarters of degrees (if the scale is large enough); drawing lines across the chart through every 5 or 10 degrees; let the degrees of latitude and longitude have their respective numbers annexed, and the sheet is then fitted to receive the places intended to be delineated thereon.

On a straight slip of pasteboard, or stiff paper, let the scale of degrees and parts of degrees of longitude, in the line AD, be laid close to the edge; and the divisions numbered from the right hand towards the left, being all west longitude.

Seek in a geographical table for the latitudes and longitudes of the places contained within the proposed limits; and let them be written out in the order in which they increase in latitude.

Then, to lay down any place, lay the edge of the pasteboard scale to the divisions on each side the chart, showing the latitude of the place; so that the beginning of its divisions falls on the right-hand border AB; and against the division showing the longitude of the given place make a point, and this gives the position of the place proposed; and in like manner are all the other places to be laid down.

Draw waving lines from one point to the other, where the coast is contiguous, and thus the representation of the lands within the proposed limits will be delineated.

Write the names to the respective parts, and in some convenient place insert a compass, and the chart will be completed.

2. The angle formed by the meridian and rhumb that a ship sails upon, is called, as we have said, the ship's course. Thus, if a ship sails on the N.N.E. rhumb, then her course will be 22° 30′; and so of others, as is manifest from the following table of the angles which every point of the compass makes with the meridian.

North.	South.	Points.	D. M.	North.	South.
		¼	2.49		
		½	5.37		
		¾	8.26		
N. by E.	S. by E.	1	11.15	N. by W.	S. by W.
		1 ¼	14. 4		
		1 ½	16.52		
		1 ¾	19.41		
N. N. E.	S. S. E.	2	22.30	N. N. W.	S. S. W.
		2 ¼	25.19		
		2 ½	28. 7		
		2 ¾	30.56		
N. E. by N.	S. E. by S.	3	33.45	N. W. by N.	S. W. by S.
		3 ¼	36.34		
		3 ½	39.22		
		3 ¾	42.11		
N. E.	S. E.	4	45. 0	N. W.	S. W.
		4 ¼	47.49		
		4 ½	50.37		
		4 ¾	53.26		
N. E. by E.	S. E. by E.	5	56.15	N. W. by W.	S. W. by W.
		5 ¼	59. 4		
		5 ½	61.52		
		5 ¾	64.42		
E. N. E.	E. S. E.	6	67.30	W. N. W.	W. S. W.
		6 ¼	70.19		
		6 ½	73. 7		
		6 ¾	75.56		
E. by N.	E. by S.	7	78.45	W. by N.	W. by S.
		7 ¼	81.34		
		7 ½	84.22		
		7 ¾	87.11		
	East.	8	90. 0	West.	

3. The distance between two places lying on the same parallel counted in miles of the equator, or the distance of one place from the meridian of another counted as above on the parallel passing over that place, is called meridional distance; which, in plane sailing, goes under the name of departure.

4. Let A (fig. 2), denote a certain point on the earth's surface, AC its meridian, and AD the parallel of latitude passing though it; and suppose a ship to sail from A on the N.N.E. rhumb till she arrives at B; and through B draw the meridian BD, (which, according to the principles of plane sailing, must be parallel to CA,) and the parallel of latitude BC; then the length of AB, viz. how far the ship has sailed upon the N.N.E rhumb, is called her distance; AC or BD will be her difference of latitude, or northing; CB will be her departure, or easting; and the angle CAB will be the course. Hence it is plain, that the distance sailed will always be greater than either the difference of latitude or departure; it being the hypothenuse of a right-angled triangle, whereof the other two are the legs; except the ship sails either on a meridian or a parallel of latitude: for if the ship sails on a meridian, then it is plain, that her distance will be just equal to her difference of latitude, and she will have no departure; but if she sails on a parallel, then her distance will be the same with her departure, and she will have no difference of latitude. It is evident also from the figure, that if the course is less than 4 points, or 45 degrees, its complement, viz. the other oblique angle, will be greater than 45 degrees, and so the difference of latitude will be greater than the departure; but if the course is greater than four points, then the difference of latitude will be less than the departure; and lastly, if the course is just four points, the difference of latitude will be equal to the departure.

5. Since the distance, difference of latitude, and departure, form a right-angled triangle, in which the oblique angle opposite to the departure is the course, and the other its complement; therefore, having any two of these given, we can (by plane trigonometry) find the

rest; and hence arise the cases of plane-sailing, which are as follow:

CASE I. Course and distance given, to find the difference of latitude and departure.

Example. Suppose a ship sails from the latitude of 30° 25′ north, N. NE. 32 miles (fig. 3). Required the difference of latitude and departure, and the latitude come to. Then (by right-angled trigonometry) we have the following analogy for finding the departure, viz.

As radius - - -		10.00000
to the distance AC -	32.	1.50515
so is the sine of the course A	22° 30′	9.58284
to the departure BC -	12.25	1.08799

so the ship has made 12.25 miles of departure easterly, or has got so far to the eastward of her meridian. Then for the difference of latitude or northing the ship has made, we have (by rectangular trigonometry) the following analogy, viz.

As radius - - - -		10.00000
is the distance AC -	32	1.50515
so is the co-sine of course A	22° 30′	9.58284
to the difference of lat. AB	29.57	1.47077

so the ship has differed her latitude, or made of northing, 29.57 minutes.

And since her former latitude was north, and her difference of latitude also north; therefore,

To the latitude sailed from -	30°, 25′ N
add the difference of latitude	00°, 29.57
and the sum is the latitude come to	30°, 54.57′N.

By this case are calculated the tables of difference of latitude, and departure, to every degree, point, and quarter-point, of the compass.

CASE II. Course and difference of latitude given, to find distance and departure.

Example. Suppose a ship in the latitude of 45° 25′ N., sails NE*b*N$\frac{1}{2}$ easterly (Pl. XCIII. Navigation, fig. 4), till she comes to the latitude of 46° 55′ north: required the distance and departure made good upon that course.

Since both latitudes are northerly, and the course also northerly; therefore,

From the latitude come to -	46°, 55′
subtract the latitude sailed from -	45°, 25′
and there remains - - -	01° 30′
the difference of latitude, equal to	90 miles.

And (by rectangular trigonometry) we have the following analogy for finding the departure BD, viz.

As radius - - - -		10.00000
is to the diff. of latitude AB	90	1.95424
so is the tangent of course A	39°, 22′	9.91404
to the departure BD -	73.84	1.86828

so the ship has got 73.84 miles to the eastward of her former meridian.

Again, for the distance AD, we have (by rectangular trigonometry) the following proportion, viz.

As radius - - . -		10.00000
is to the secant of the course	39°, 22′	10.11176
so is the diff. of latitude AB	90	1.95424
to the distance AD -	116.4	2.06600

CASE III. Difference of latitude and distance given, to find course and departure.

Example. Suppose a ship sails from the latitude of 56° 50′ north, on a rhumb between south and west, 126 miles, and she is then found by observation to be in the latitude of 55°, 40′ north: required the course she sailed on, and her departure from the meridian. (Fig. 5.)

Since the latitudes are both north, and the ship sailing towards the equator; therefore,

From the latitude sailed from -	56°, 50′
subtract the observed latitude -	55°, 40′
and the remainder - -	01°. 10

equal to 70 miles, is the difference of latitude.

By rectangular trigonometry we have the following proportion for finding the angle of the course F, viz.

As the distance sailed DF	126	2.10037
is to radius - -		10.00000
so is the diff. of latitude FE	70	1.84510
to the co-sine of the course F.	56°, 15′	9.74473

which, because she sails between south and west, will be south 56° 15′ west, or SW*b*W. Then, for the departure, we have (by rectangular trigonometry) the following proportion, viz.

As radius - - -		10.00000
is to the distance sailed DF	126	2.10037
so is the sine of the course F	56°, 15′	9.91985
to the departure DE	104.8	2.02022

consequently she has made 104.8 miles of departure westerly.

CASE IV. Difference of latitude and departure given, to find course and distance.

Example. Suppose a ship sails from the latitude of 44° 50′ north, between south and east, till she has made 64 miles of easting, and is then found by observation to be in the latitude of 42° 56′ north: required the course and distance made good.

Since the latitudes are both north, and the ship sailing towards the equator; therefore,

From the latitude sailed from	44°, 50′N
take the latitude come to -	42°, 56′
and there remains - -	01°, 54′

equal to 114 miles, the difference of latitude or southing.

In this case (by rectangular trigonometry) we have the following proportion to find the course KGL (fig. 6), viz.

As the diff. of latitude GK	114	2.05690
is to radius - - -		10,00000
so is the departure KL	64	1.80618
to the tangent of course G	29°, 19′	9.74928

which, because the ship is sailing between south and east, will be south 29° 19′ east, or SSE$\frac{1}{2}$ east nearly.

Then for the distance, we shall have (by rectangular trigonometry) the following analogy, viz.

As radius - - -		10.00000
is to the diff. of latitude GK	114	2.05690
so is the secant of the course	29°, 19′	10.05952
to the distance GL -	130.8	2.11642

consequently the ship has sailed on a SSE$\frac{1}{2}$ east course 130.8 miles.

CASE V. Distance and departure given, to find the course and difference of latitude.

Example. Suppose a ship at sea sails from the latitude of 34° 24′ north, between north and west, 124 miles, and

is found to have made of westing 86 miles: required the course steered, and the difference of latitude or northing made good.

In this case (by rectangular trigonometry) we have the following proportion for finding the course ADB, (fig. 7), viz.

As the distance AD -	124	2.09342
is to radius - - -		10.00000
so is the departure AB	86	1.93450
to the sine of the course D	43° 54′	9.84108

so the ship's course is north 43°45′ west, or NWbN$\frac{1}{4}$ west nearly.

Then for the difference of latitude, we have (by rectangular trigonometry) the following analogy, viz.

As radius - - - -		10.00000
is to the distance AD	124	2.09342
so is the co-sine of the course	43°,54′	9.85766
to the diff. of latitude BD	89.35	1.95108

which is equal to 1 degree and 29 min. nearly.

Hence, to find the latitude the ship is in, since both latitudes are north, and the ship sailing from the equator; therefore,

To the latitude sailed from -	34°, 24′
add the difference of latitude -	1 , 29
the sum is - - -	35 , 53

the latitude the ship is in north.

CASE VI. Course and departure given, to find distance and difference of latitude.

Example. Suppose a ship at sea, in the latitude of 24° 30′ south, sails SEbS, till she has made of easting 96 miles: required the distance and difference of latitude made good on that course.

In this case (by rectangular trigonometry and by case 2,) we have the following proportion for finding the distance (fig. 8), viz.

As the sine of the course G	33°, 45′	9.74474
is to the departure HM	96	1.98227
so is radius - - -		10.00000
to the distance GM -	172.8	2.23753

Then, for the difference of latitude, we have (by rectangular trigonometry) the following analogy, viz.

As the tangent of course	33°, 45′	9.82489
is to the departure HM	96	1.98227
so is radius - - - -		10.00000
to the difference of lat. GH	143.7	2.15738

equal to 2°, 24′ nearly. Consequently, since the latitude the ship sailed from was south, and she sailing still towards the south,

To the latitude sailed from -	24°, 30′
add the difference of latitude -	2 , 24
and the sum - - -	26 , 54

is the latitude she has come to south.

6. When a ship sails on several courses in 24 hours, the reducing all these into one, and thereby finding the course and distance made good upon the whole, is commonly called the resolving of a traverse.

7. At sea they commonly begin each day's reckoning from the noon of that day, and from that time they set down all the different courses and distances sailed by the ship till noon next day upon the log-board; then from these several courses and distances, they compute the difference of latitude and departure for each course (by Case I. of Plane Sailing); and these, together with the courses and distances, are set down in a table, called the Traverse Table, which consists of five columns: in the first of which are placed the courses and distances; in the two next, the difference of latitude belonging to these courses, according as they are north or south; and in the two last are placed the departures belonging to these courses, according as they are east or west. Then they sum up all the northings and all the southings; and taking the difference of these, they know the difference of latitude made good by the ship in the last 24 hours, which will be north or south, according as the sum of the northings or southing is greatest: the same way, by taking the sum of all the eastings, and likewise of all the westings, and subtracting the lesser of these from the greater, the difference will be the departure made good by the ship during the last 24 hours, which will be east or west according as the sum of the eastings is greater or less than the sum of the westings; then from the difference of latitude and departure made good by the ship during the last 24 houes, found as above, they find the true course and distance made good upon the whole (by Case 4 of Plane Sailing), as also the course and distance to the intended port.

Example. Suppose a ship at sea, in the latitude of 48° 24′ north, at noon any day, is bound to a port in the latitude of 43° 40′ north, whose departure from the ship is 144 miles east; consequently the direct course and distance of the ship is SSE. $\frac{1}{2}$ east 315 miles; but by reason of the shifting of the winds she is obliged to steer the following course till noon next day, viz. SEbS 56 miles, SSE 64 miles, NWbW 48 miles, SbW $\frac{1}{2}$ west 54 miles, and SEbS $\frac{1}{2}$ east 74 miles: required the course and distance made good the last 24 hours, and the bearing and distance of the ship from the intended port.

The solution of this traverse depends entirely on the 1st and 4th Cases of Plane Sailing; and first we must (by Case 1.) find the difference of latitude and departure for each course. Thus,

1. Course SEbS distance 56 miles.

For departure.

As radius - - -		10.00000
is to the distance -	56	1.74819
so is the sine of the course	33°, 45,	9.74474
to the departure -	31.11	1.49293

For difference of latitude.

As radius - - - -		1.00000
is to the distance -	56	1.74819
so is the co-sine of the course	33°, 45′	9.91985
to the diff. of latitude -	46.57	1.66304

2. Course SSE and distance 64 miles.

For departure.

As radius - - -		10.00000
is to the distance -	64	1.80618
so is the sine of the course	22°, 30′,	2.58284
to the departure -	24.5	1.38902

For the difference of latitude.

As radius - - -		10.00000
is to the distance -	64	1.80618
so is the co-sine of the course	22°. 30′	9.96562
to the difference of latitude	59.13	1.77180

3. Course NWbW and distance 48 miles.

For departure.

As radius - - - -		10.00000
is to the distance -	48	1.68124
so is the sine of the course	56°, 15′	9.91985
to the departure -	39.91	1.60109

For difference of latitude.

As radius - - -		10.00000
is to the distance -	48	1.68124
so is the co-sine of the course	56°, 15′	9.74474
to the difference of latitude	26.67	1.42598

4. Coarse SbW $\frac{1}{2}$ west and distance 54 miles.

For departure.

As radius - - -		10.00000
is to the distance -	54	1.73239
so is the sine of the course	16°, 52′	9.46262
to the departure -	15.67	8.19501

For difference of latitude.

As radius - - -		10.00000
is to the distance - -	54	1.73239
so is the co-sine of the course	16°, 52′	9.98090
to the difference of latitude	51.67	1.71329

5, Course SEbS $\frac{1}{2}$ east and distance 74 miles.

For departure.

As radius - - -		10.00000
is to the distance -	74	1.86923
so is the sine of the course	39°, 22′	9.80228
to the departure .	46.94	1.67151

For difference of latitude.

As radius - - -		10.00000
is to the distance -	74	1.80923
so is the co-sine of the course	39° 22′	9.88824
to the difference of latitude	57.21	1.75747

Now these several courses and distances, together with the differences of latitude and departures deduced from them, being set down in the proper columns in the traverse table, will stand as follow:

THE TRAVERSE TABLE.

Courses.	Distances.	Diff. of Lat.		Departure.	
		N.	S.	E.	W.
SE b S	— 56	—	46.57	31.11	—
S SE	— 64	—	59.13	24.5	—
NW b W	— 48	26.67	—	—	39.91
S b W $\frac{1}{2}$ W	— 54	—	51.67	—	15.67
SE b S $\frac{1}{2}$ E	— 74	—	57.21	46.94	—
		26.67	214.58	102.55	55.58
			26.67	55.58	
	Diff. of Lat.		187.91	46.97	Dep.

From the above table it is plain, since the sum of the northings is 26.67, and of the southings 214.58, the difference between these, viz. 187.91, will be the southing made good by the ship the last 24 hours; also the sum of the eastings being 102.55, and of the westings 55.58, the difference 46.97 will be the easting or departure made good by the ship's last 24 hours, consequently, to find the true course and distance made good by the ship in that time, it will be (by Case 4. of Plane Sailing),

As the difference of latitude	187.91	2.27393
is to the radius - - -		10.00000
so is the departure -	46.97	1.67182
to the tangent of the course	14°, 03′	9.39789

which is SbE $\frac{1}{4}$ east nearly. Then for the distance, it will be,

As radius - - - -		10.00000
is to the difference of latitude	117,91	2.27393
so is the secant of the course	14°, 03′	10.01319
to the distance -	193.7	2.28712

consequently the ship has made good the last 24 hours, on a SbE $\frac{1}{4}$ east course, 193.7 miles: and since the ship is sailing towards the equator; therefore,

From the latitnde sailed from	48°, 24′ N
take the diff. of latitude made good	3, 08 S
there remains - - -	45, 16 N

the latitude the ship is in north. And because the port the ship is bound for lies in the latitude of 43° 40′ N. and consequently south of the ship; therefore,

From the latitude the ship is in	45°, 16′ N
take the latitude she is bound for	43 , 40 N
and there remains - -	1 , 36

or 95 miles, the difference of latitude or southings the ship has to mack. Again, the whole easting the ship had to make being 144 miles, and she having already made 46.97, or 47 miles of easting; therefore the departure or easting she still has to make will be 97 miles: consequently, to find the direct course and distance between the ship and the intended port, it will be, (by Case 4. of Plane Sailing),

As the difference of latitude	96	1.98227
is to radius - - -		10.00000
so is the departure -	97	1.98677
to the tangent of the course	45°, 19′	10.00450

And

As radius - - - -		10.00000
is to the difference of latitude	96	1.98227
so is the secant of the course	45°, 19′	10.15293
to the distance - -	136.5	2.13620

whence the true bearing and distance of the intended port is, SE 136.5 miles.

Of Parallel Sailing. Since the parallels of latitude do always decrease the nearer they approach the pole, it is plain a degree on any of them must be less than a degree upon the equator. Now in order to know the length of a degree on any of them, let PB (fig. 9) represent half the earth's axis, PA a quadrant of a meridian, and consequently A a point on the equator, C a point on the meridian, and CD a perpendicular from that point upon the axis, which plainly will be the sine of CP the distance of that point from the pole, or the co-sine of CA its distance from the equator; and CD will be to AB, as the sine of CP, or cosine of CA, is to the radius. Again, if the quadrant PAB is turned round upon the axis PB, it is plain the point A will describe the circumference of the equator whose radius is AB, and any other point C upon the meridian will describe the circumference of a parallel whose radius is CD.

Cor. 1. Hence (because the circumference of circles are as their radii) it follows, that the circumference of

any parallel is to the circumference of the equator, as the co-sine of its latitude is to radius.

Cor. 2. And since the wholes are as their similar parts, it will be, As the length of a degree on any parallel, is to the length of a degree upon the equator, so is the co-sine of the latitude of that parallel, to radius.

Cor. 3. Hence, As radius, is to the co-sine of any latitude, so are the minutes of difference of longitude between two meridians, or their distance in miles upon the equator, to the distance of these two meridians on the parallel in miles.

Cor. 4. And, As the co-sine of any parallel, is to radius, so is the length of any arch on that parallel (intercepted between two meridians) in miles, to the length of a similar arch on the equator, or minutes of difference of longitude.

Cor. 5. Also, As the co-sine of any one parallel, is to the co-sine of any other parallel, so is the length of any arch on the first in miles, to the length of the same arch on the other in miles.

From what has been said, arises the solution of the several cases of parallel sailing, which are as follow:

Case I. Given the difference of longitude between two places, both lying on the same parallel; to find the distance between those places.

Example I. Suppose a ship in the latitue of 54° 20′ north, sails directly west on that parallel till she has differed her longitude 12° 45′; required the distance sailed on that parallel.

First, The difference of longitude reduced into minutes, or nautical miles, is 765°, which is the distance between the meridian sailed from, and the meridian come to, upon the equator; then to find the distance between these meridians on the parallel of 54° 20′, or the distance sailed, it will be, by Cor. 3. of the last article,

As radius - - - -		10.00000
is to the co-sine of the lat.	54° 20′	9.76572
so are the minutes of diff. lon.	765	2.18366
to the distance on the parallel	446.1	2.64938

Example 2. A degree on the equator being 60 minutes or nautical miles; required the length of a degree on the parallel of 51° 32′.

By Cor. 3. of the last article, it will be

As radius - - -		10.00000
is to the co-sine of the latitude	51°, 32′	9.79383
so are the min. in 1° on the equa.	60	1.77815
to - - -	37.32	1.57198

the miles answering to a degree on the parallel of 51° 32′.

By this problem a table is constructed, showing the geographic miles answering to a degree on any parallel of latitude; in which you may observe, that the columns marked at the top with D. L. contain the degrees of latitude belonging to each parallel: and the adjacent columns marked at the top Miles, contain the geographic miles answering to a degree upon these parallels. See the table in the article Map.

Though the table does only show the miles answering to a degree of any parallel, whose latitude consists of a whole number of degrees; yet it may be made to serve for any parallel whose latitude is some number of degrees and minutes, by making the following proportion, viz.

As 1 degree, or 60 minutes, is to the difference between the miles answering to a degree in the next greater and next less tabular latitude than that proposed; so is the excess of the proposed latitude above the next tabular latitude, to a proportional part; which, subtracted from the miles answering to a degree of longitude in the next less tabular latitude, will give the miles answering to a degree in the proposed latitude.

Example. Required to find the miles answering to a degree on the parallel of 56° 44′.

First, The next less parallel of latitude in the table than that proposed, is that of 56°, a degree of which (by the table) is equal to 33.55 miles; and the next greater parallel of latitude in the table, than that proposed, is that of 57°, a degree of which is (by the table) equal to 32.68 miles; the difference of these is 87, and the distance between these parallels is 1 degree, or 60 minutes; also the distance between the parallel of 56°, and the proposed parallel of 56° 44′, is 44 minutes: then, by the preceding proportion, it will be, As 60 is to 87, so is 44 to 638, the difference between a degree on the parallel of 56° and a degree on the parallel of 56° 44′; which, therefore, taken from 33.55, the miles answering to a degree on the parallel of 56°, leaves 32.912, the miles answering to a degree on the parallel of 56° 44′, as was required.

Case II. The distance sailed in any parallel of latitude, or the distance between any two places on that parallel, being given; to find the difference of longitude.

Example. Suppose a ship in the latitude of 55° 36′ north, sails directly east 685.6 miles: required how much she has differed her longitude.

By Cor. 4. Art. 1. of this section, it will be

As the co-sine of the lat.	55° 36′	9.75202
is to radius - - -		10.00000
so is the distance sailed	685.6	2.83607
to minute of difference of lon.	1213	3.08405

which reduced into degrees, by dividing by 60, makes 20° 13′, the difference of longitude the ship has made.

This also may be solved by help of the preceding table, viz. by finding from it the miles answering to a degree on the proposed parallel, and dividing with this the given number of miles, the quotient will be the degrees and minutes of difference of longitude required.

Thus in the last example, we find, from the foregoing table, that a degree on the parallel of 55° 36′ is equal to 33.89 miles; by this we divide the proposed number of miles 685.6, and the quotient is 20.13 degrees, *i. e.* 20° 13′, the difference of longitude required.

Case III. The difference of longitude between two places on the same parallel, and the distance between them, being given; to find the latitude of that parallel.

Example. Suppose a ship sails on a certain parallel directly west 624 miles, and then has differed her longitude 18° 46′, or 1126 miles: required the latitude of the parallel she sailed upon; it will be by Cor. 3 before

As the min. of diff. long. 1.	126	3.05154
is to the distance sailed	624	2.79518
so is radius - - - -		10.00000
to the co-sine of the lat.	56°, 21′	9.74364

consequently the latitude of the ship, or parallel she sailed upon, was 56° 21′.

From what has been said, may be solved the following problems;

Prob. I. Suppose two ships in the latitude of 46° 30′ north, distant asunder 654 miles, sail both directly north 256 miles, and consequently are come to the latitude of 50° 46′ north: required their distance on that parallel.

By Cor. 5. Art. 1. of this section, it will be,

As the co-sine of	46°, 30′	9.83781
is to the co-sine of	50°, 46′	9.80105
so is - -	654 -	2.81558
to - - -	601 -	2.77882

the distance between the ships when on the parallel of 50° 46′.

Prob. II. Suppose two ships in the latitude of 45° 48′ north, distant 846 miles, sail directly north till the distance between them is 624 miles: required the latitude come to, and the distance sailed.

By Cor. 5. Art. 1. of this section, it will be,

As their first distance	846	2.92737
is to their second distance	624	2.79518
so is the co-sine of -	45°, 48′	9.84334
to the co-sine - -	59°, 04′	9.71115

the latitude of the parallel the ships are come to.

Consequently, to find their distance sailed,

From the latitude come to -	59°, 04′
subtract the latitude sailed from -	45 , 48
and there remains - -	13 , 16

equal to 796 miles, the difference of latitude or distance sailed.

Of Middle-latitude Sailing.—1. When two places lie both on the same parallel, we have shown how, from the difference of longitude given, to find the miles of easting or westing between them, *et e contra*. But when two places lie not on the same parallel, then their difference of longitude cannot be reduced to miles of easting or westing on the parallel of either place: for if counted on the parallel of that place that has the greatest latitude, it would be too small; and if on the parallel of that place having the least latitude, it would be too great. Hence the common way of reducing the difference of longitude between two places, lying on different parallels, to miles of easting or westing, *et e contra*, is by counting it on the middle parallel between the two places, which is found by adding the latitudes of the two places together, and taking half the sum, which will be the latitude of the middle parallel required. And hence arises the solution of the following cases:

Case I. The latitudes of two places, and their difference of longitude, given; to find the direct course and distance.

Example. Required the direct course and distance between the Lizard in the latitude of 50° 0′ north, and longitude 5° 14′ west, and St. Vincent in the latitude of 17° 10′ north, and longitude of 24° 20′ west.

First. To the latitude of the Lizard	50°	00′N
add the latitude of St. Vincent	17	10
The sum is - - - - -	67	10
Half the sum or latitude of the middle parallel is - - - - -	33	35 N
Also the difference of latitude is	33	50

equal to 1970 miles of southing. Again,

From the longitude of St. Vincent	24	20 W
take the longitude of the Lizard	5	14
there remains - - - -	16	6

equal to 1146 min. of diff. of lon. west.

Then for the miles of westing, or departure, it will be (by Case I. of Parallel Sailing),

As radius - - - -		10.00000
is to the co-sine of the middle parallel	33°, 35′	9.92069
so is min. diff. of lon.	1146	3.05918
to the miles of westing	954.7	2.97987

And for the course it will be (by Case 4. of Plain Sailing),

As the diff. of lat. -	1970	3.29447
is to radius - - - -		10.00000
so is the departure	954.7	2.97987
to the tang. of the course	25°, 51′	9.68540

which, because it is between south and west, will be SSW $\frac{1}{4}$ west nearly.

For the distance, it will be, by the same case,

As radius - - - -		10.00000
is to the diff. of lat.	1970	3.29447
so is the secant of the course	25°, 51′	10.04579
to the distance -	2189	3.34026

whence the direct course and distance from the Lizard to St. Vincent are SSW $\frac{1}{4}$ 2189 W. miles.

Case II. One latitude, course, and distance sailed, being given; to find the other latitude, and difference of longitude.

Example. Suppose a ship in the latitude of 50° 00′ north, sails south 50° 06′ west, 150 miles; required the latitude the ship has come to, and how much she has differed her longitude.

First. For the difference of latitude, it will be, (by Case 1. of Plane Sailing,)

As radius - - -		10.00000
is to the distance -	150	2.17609
so is the co-sine of the course	50°, 06′	9.80716
to the diff. of latitude	96.22	1.98325

equal to 1°, 36′. And since the ship is sailing towards the equator: therefore,

From the latitude she was in -	50°, 00′
take the difference of latitude -	1 , 36
and there remains - - -	48 , 24

the latitude she has come to north. Consequently the latitude of the middle parallel will be 49° 12′.

Then for departure or westing it will be, by the same Case,

As radius - - - -		10.00000
is to the distance -	150	2.17609
so is the sine of the course	50°, 06′	9.88489
to the departure -	115.1	2.06098

As for the difference of longitude, it will be, (by Case 2. of Plane Sailing,)

As the co-s. of the middle par.	49° 12′	9.81519
is to radius - - -		10.00000
so is the departure -	115.1	2.06098
to the min. diff. of longitude	176.1	2.24579

equal to 2° 56′, which is the difference of longitude the ship has made westerly.

CASE III. Course and difference of latitude given; to find the distance sailed, and difference of longitude.

Example. Suppose a ship in the latitude 53° 34′ north, sails SE*b*S, till by observation she is found to be in the latitude of 51° 12 , and consequently has differed her latitude of 2° 22′, or 142 miles: required the distance sailed, and the difference of longitude.

First, for the departure, it will be, (by Case 2. of Plane Sailing,)

As radius - - - -		10.00000
is to the diff. of latitude	142	2.15229
so is the tang. of course	33°, 45′	9.82489
to the departure -	94.88	1.97718

And for the distance it will be, (by the same Case,)

As radius - - - -		10.00000
is to the diff. of latitude	142	2.15229
so is the secant of the course	33°, 45′	10 08015
to the distance - -	170.8	2.23244

Then, since the latitude sailed from was 53° 34′ north, and the latitude come to 51° 12′ north; therefore the middle parallel will be 52° 23′; and consequently, for the difference of longitude, it will be, (by Case 2. of Parallel Sailing.)

As the co-sine of the mid. par.	52°, 23′	9.78560
is to the departure -	94.88	1.97718
so is radius - - - -		10.00000
to min. of diff. of longitude	155.5	2.19158

equal to 2° 35′, the difference of longitude easterly.

CASE IV. Difference of latitude and distance sailed, given; to find the course and difference of longitode.

Example. Suppose a ship in the latitude of 43° 26′ north, sails between south and east, 246 miles, and then is found by observation to be in the latitude of 41° 06′ north: required the direct course and difference of longitude.

First, for the course, it will be, (by Case 3. of Plane Sailing,)

As the distance -	246	2.30094
is to radius - - - -		10.00000
so is the diff. of latitude	140	2.14613
to the co-sine of the course	55°, 19′	9.75519

which, because the ship sails between south and east, will be south 55° 19′ east, or SE*b*E nearly.

Then, for departure, it will be, by the same Case,

As radius - - - -		10.00000
is to the distance -	246	2.39094
so is the sine of the course	55°, 19′	9.91504
to the departure -	202,3	2.30598

Lastly, For the difference of longitude, it will be, (by Case 2. of Parallel Sailing,)

As the co-sine of the mid. par.	42°, 16′	9.86924
is to the departure -	303.8	2.30598
so is radius - - -		10.00000
to min. of diff. of longitude	273.3	2.43674

equal to 4° 33′, the difference of longitude easterly.

CASE V. Course and departure given; to find difference of latitude, difference of longitude, and distance sailed.

Example. Suppose a ship in the latitude of 48° 23′ north, sails SW*b*S, till she has made of westing 123 miles: required the latitude come to, the difference of longitude, and the distance sailed.

First, For the distance, it will be, (by Case 6. of Plane Sailing,)

As the sine of the course	33°, 45′	6.74474
is to the departure -	123	2.08991
so is radius - - -		10.00000
to the distance -	221.4	2.34517

And for the difference of latitude, it will be, by the same Case,

As the tang. of course	33°, 45′	9.82489
is to the departure -	123	2.08991
so is radius - - -		10.00000
to the diff. of latitude	184	2.26502

equal to 3° 04′; and since the ship is sailing towards the equator, the latitude come to will be 45° 19′ north; and consequently the middle parallel will be 46° 51′.

Then to find the difference of longitude, it will be, (Case 2. of Parallel Sailing.)

As the co-sine of mid. par.	46°, 51′	9.83500
is to the departure -	123	2.08991
so is radius - - -		10.00000
to min. of diff. of longitude	180	2.25491

which is equal to 3° 00′, the difference of longitude westerly.

CASE VI. Difference of latitude and departure given; to find course, distance, and difference of longitude.

Example. Suppose a ship in the latitude of 46° 37′ north, sails between south and east, till she has made of easting 146 miles, and is then found by observation to be in the latitode of 43° 24′ north: required the course, distance, and difference of longitude.

First, by Case 4. of Plane Sailing, it will be for the course,

As the diff. of latitude	193	2.28556
is to the departure -	146	2.16137
so is radius - - -		10.00000
to the tang. of the course	36°, 55′	9.87581

which, because the ship is sailing between south and east, will be south 36° 55′ east, or SE*b*S¼ east nearly.

For the distance, it will be, by the same Case,

As radius - - -		10.00000
is to the diff. of latitude	193	2.28556
so is the secant of the course	36°, 55′	10.09718
to the distance -	241.4	2.38274

Then for the difference of longitude, it will be by Case 2. of Parallel Sailing,

As the co-sine of the mid. par.	45°, 00′	9.84949
is to the departure -	146	2.16137
so is radius - - - -		10.00000
to min. of diff. of longitude	205	2.31188

equal to 3° 25′, the difference of longitude easterly.

CASE VII. Distance and departure given; to find difference of latitude, course, and difference of longitude.

Example. Suppose a ship in the latitude 33° 40′ north, sails between south and east 165 miles, and has then made of easting 112.5 miles: required the difference of latitude, course, and difference of longitude.

First, for the course, it will be, by Case 5. of Plane Sailing,

As the distance -	165	2.21748
is to radius - - -		10.00000
so is the departure -	102.5	2.05115
to the sine of the course	42°, 59′	9.83367

which, because the ship sails between south and east, will be south 42° 59′ east, or SE*b*E¾ east nearly.

And for the difference of latitude, it will be, by the same Case,

As radius - - -		10.00000
is to the distance -	165	2.21748
so is the co-sine of the course	42° 59′	9.86436
to the difference of latitude	120.7	2.08184

equal to 2° 00′; consequently the latitude come to will be 31° 40′ north, and the latitude of the middle parallel will be 32° 40′. Hence, to find the difference of longitude, it will be, by Case 2. of Parallel Sailing,

As the co-sine of the mid. par.	32°, 40′	9.92522
is to the departure -	112.5	2.05115
so is radius - - -		10.00000
to min. of diff. of long.	133.6	2.12593

equal to 2° 13′ nearly, the difference of longitude easterly.

Case VIII. Difference of longitude and departure given; to find difference of latitude, course, and distance sailed.

Example. Suppose a ship in the latitude of 50° 46′ north, sails between south and west, till her difference of longitude is 3° 12′, and is then found to have departed from her former meridian 126 miles: required the difference of latitude, course, and distance sailed.

First, for the latitude she has come to, it will be, by Case 3. of Parallel Sailing,

As min. of diff. of long.	192	2.28330
is to the departure -	126	2.10037
so is radius - - -		10.00000
to the co-sine of mid. par.	48°, 59′	9.81707

Now, since the middle latitude is equal to half the sum of the two latitudes (by art. 1. of this sect.) and so the sum of the two latitudes equal to double the middle latitude; it follows, that if from double the middle latitude we subtract any one of the latitudes, the remainder will be the other. Hence from twice 48° 59′, viz. 97° 58′, taking 50° 46′ the latitude sailed from, there remains 47° 12′ the latitude come to; consequently the difference of latitude is 3° 34′, or 214 minutes.

Then, for the course, it will be, by Case 4. of Plane Sailing,

As difference of latitude	214	2.33041
is to radius - - - -		10.00000
so is the departure -	126	2.10037
to the tang. of the course	30° 29′	9.76996

which, because it is between south and west, will be south 30° 29 west, or SSW$\frac{3}{4}$ west nearly.

And for the distance, it will be, by the same Case,

As radius - - -		10.00000
is to the difference of lat.	214	2.33041
so is the secant of the course	30°, 29′	10.06461
to the distance - -	248.4	2.39502

2. From what has been said, it will be easy to solve a traverse by the rules of Middle-latitude Sailing.

Example. Suppose a ship in the latitude of 43° 25′ north, sails upon the following courses, viz. SW*b*S 63 miles, SSW$\frac{1}{2}$ west 45 miles, S*b*E 54 miles, and SW*b*W 74 miles: required the latitude the ship has come to, and how far she has differed her longitude.

First, By Case 2. of this sect. find the difference of latitude and difference of longitude belonging to each course and distance, and they will stand as in the following table:

Courses.	Distances.	Diff. of Lat.		Diff. of Long.	
		North.	South.	East.	West.
SW*b*S -	63	—	52.4	—	47.85
SSW$\frac{1}{2}$W -	45	—	39.7	—	28.62
S*b*E -	54	—	53.0	14.75	—
SW*b*W -	74	—	41.1	—	81.08
					157.55
	Diff. of Lat.		186.2		13.75
			Diff. of Long.		143.80

Hence it is plain the ship has differed her latitude 186.2 minutes, or 3° 6′, and so has come to the latitude of 40° 19′ north, and has made of difference of longitude 143.8 minutes, or 2° 23′ 48″, westerly.

3. This method of sailing, though it is not strictly true, yet comes very near the truth, as will be evident by comparing an example wrought by this method with the same wrought by the method delivered in the next section, which is strictly true; and it serves, without any considerable error, in runnings of 450 miles between the equator and parallel of 30 degrees, of 300 miles between that and the parallel of 60 degrees, and of 150 miles as far as there is any occasion, and consequently must be sufficiently exact for 24 hours run.

Of Mercator's Sailing. Though the meridians do all meet at the pole, and the parallels to the equator do continually decrease, and that in proportion to the co-sines of their latitudes; yet in old sea-charts the meridians were drawn parallel to one another, and consequently the parallels of latitude made equal to the equator, and so a degree of longitude on any parallel as large as a degree on the equator; also in these charts the degrees of latitude were still represented (as they are in themselves) equal to each other, and to those of the equator. By these means the degrees of longitude being increased beyond their just proportion, and the more so the nearer they approach the pole, the degrees of latitude at the same time remaining the same, it is evident places must be very erroneously marked down upon these charts with respect to their latitude, and consequently their bearing from one another very false.

To remedy this inconvenience, so as still to keep the meridians parallel, it is plain we must protract, or lengthen, the degrees of latitude in the same proportion as those of longitude are, that so the proportion in easting and westing may be the same with that of southing and northing, and consequently the bearings of places from one another are the same upon the chart as upon the globe itself.

Let ABD (fig. 10.) be a quadrant of a meridian, A the pole, D a point on the equator, AC half the axis, B any point upon the meridian, from which draw BF perpendicular to AC, and BG perpendicular to DC; then BG will be the sine, and BF or CG the co-sine, of BD the latitude of the point B; draw DE the tangent and CE the secant of the arch CD. It has been demonstrated, that any arch of a parallel is to the like arch of the equator, as the co-sine of the latitude of that parallel is to radius. Thus any arch, as a minute on the parallel described by the point B, will be a minute on the equator, as BF or CG is to CD;

but since the triangles CGB, CDE, are similar, therefore CG will be to CD as CB is to CE, *i. e.* the co-sine of any parallel is to radius as radius is to the secant of the latitude of that parallel. But it has been just now shown, that the co-sine of any parallel is to radius, as the length of any arch (as a minute) on that parallel is to the length of the like arch on the equator; therefore the length of any arch (as a minute) on any parallel, is to the length of the like arch on the equator, as radius is to the secant of the latitude of that parallel; and so the length of any arch (as a minute) on the equator, is longer than the like arch of any parallel, in the same proportion as the secant of the latitude of that parallel is to radius. But since in this projection the meridians are parallel, and consequently each parallel of latitude equal to the equator, it is plain the length of any arch (as a minute) on any parallel, is increased beyond its just proportion, at such rate as the secant of the latitude of that parallel is greater than radius; and therefore, to keep up the proportion of northing and southing to that of easting and westing, upon this chart, as it is upon the globe itself, the length of a minute upon the meridian at any parallel must also be increased beyond its just proportion at the same rate, *i. e.* as the secant of the latitude of that parallel is greater than radius. Thus to find the length of a minute upon the meridian at the latitude of 75 degrees, since a minute of a meridian is every where equal on the globe, and also equal to a minute upon the equator, let it be represented by unity; then making it as radius to the secant of 75 degrees, so is unity to a fourth number, which is 3.864 nearly; and consequently, by whatever line you represent one minute on the equator of this chart, the length of one minute on the enlarged meridian at the latitude of 75 degrees, or the distance between the parallel of 75° 00′ and the parallel of 75° 01′, will be equal to 3 of these lines, and $\frac{864}{1000}$ of one of them. By making the same proportion, it will be found that the length of a minute on the meridian of this chart at the parallel of 60°, or the distance between the parallel of 60° 00′ and that of 60° 01′, is equal to two of these lines. After the same manner, the length of a minute on the enlarged meridian may be found at any latitude; and consequently beginning at the equator, and computing the length of every intermediate minute between that and any parallel, the sum of all these shall be the length of a meridian intercepted between the equator and that parallel; and the distance of each degree and minute of latitude from the equator upon the meridian of this chart, computed in minutes of the equator, forms what is commonly called a table of meridional parts.

If the arch BD (fig. 10.) represents the latitude of any point B, then (CD being radius) CE will be the secant of that latitude; but it has been shown above, that radius is to secant of any latitude, as the length of a minute upon the equator is to the length of a minute on the meridian of this chart at that latitude; therefore CD is to CE, as the length of a minute on the equator is to the length of a minute upon the meridian at the latitude of the point B. Consequently, if the radius CD is taken equal to the length of a minute upon the equator, CE, or the secant of the latitude, will be equal to the length of a minute upon the meridian at that latitude. Therefore, in general, if the length of a minute upon the equator is made radius, the length of a minute upon the enlarged meridian will be every where equal to the secant of the arch contained between it and the equator.

Hence it follows, since the length of every intermediate minute between the equator and any parallel is equal to the secant of the latitude, (the radius being equal to a minute upon the equator), the sum of all these lengths, or the distance of that parallel on the enlarged meridian from the equator, will be equal to the sum of all the secants to every minute contained between it and the equator.

Consequently, the distance between any two parallels on the same side of the equator, is equal to the difference of the sums of all the secants contained between the equator and each parallel; and the distance between any two parallels on contrary sides of the equator, is equal to the sum of the sums of all the secants contained between the equator and each parallel.

By the tables of meridional parts given by all the writers on this subject, may be constructed the nautical chart, commonly called Mercator's chart. See Maps.

In fig. 11, let A and E represent two places upon Mercator's chart, AC the meridian of A, and CE the parallel of latitude passing through E; draw AE, and set off upon AC the length AB equal to the number of minutes contained in the difference of latitude between the two places, and taken from the same scale of equal parts the chart was made by, or from the equator, or any graduated parallel of the chart, and through B draw BD parallel to CE meeting AE in D. Then AC will be the enlarged difference of latitude, AB the proper difference of latitude, CE the difference of longitude, BD the departure, AE the enlarged distance, and AD the proper distance, between the two places A and E; also the angle BAD will be the course, and AE the rhumb-line between them.

Now, since in the triangle ACE, BD is parallel to one of its sides CE; it is plain the triangles ACE, ABD, will be similar, and consequently the sides proportional. Hence arise the solutions of the several cases in this sailing, which are as follow:

Case I. The latitudes of two places given, to find the meridional or enlarged difference of latitude between them.

Of this case there are three varieties, viz. either one of the places lies on the equator; or both on the same side of it; or lastly, on different sides.

1. If one of the proposed places lies on the equator, then the meridional difference of latitude is the same with the latitude of the other place, taken from the table of meridional parts.

Example. Required the meridional difference of latitude between St. Thomas, lying on the equator, and St. Antonio, in the latitude of 17° 20′ north. We look in the tables for the meridional part answering to 17° 20′, and find it to be 1056.2, the enlarged difference of latitude required.

2. If the two proposed places are on the same side of the equator, then the meridional difference of latitude is found by subtracting the meridional parts answering to the least latitude from those answering to the greatest, and the difference is that required.

Example. Required the meridional difference of latitude between the Lizard in the latitude of 50° 00′ north, and Antigua in the latitude of 17° 30′ north.

From the meridional parts of	50°,00′	3474.5
subtract the merid. parts of	17 30	1066.7
there remains - -		2407.8

the meridional difference of latitude required.

3. If the places lie on different sides of the equator, then the meridional difference of latitude is found by adding together the meridional parts answering to each latitude, and the sum is that required.

Example. Required the meridional difference of latitude between Antigua in the latitude of 17° 30′ north, and Lima in Peru in the latitude of 12° 30′ south.

To the merid. parts answering to	17° 30′	1066.7
add these answering to -	12 30	756.1
the sum is - - -		1822.8

the meridional difference of latitude required.

Case II. The latitudes and longitudes of two places given; to find the direct course and distance between them.

Example. Required to find the direct course and distance between the Lizard in the latitude of 50° 00′ north, and Port Royal in Jamaica, in the latitude of 17° 40′; differing in longitude 70° 46′, Port Royal lying so far to the westward of the Lizard.

Preparation.

From the latitude of the Lizard	50° 00′
subtract the latitude of Port Royal	17 40
and there remains - - -	32 20

equal to 1940 minutes, the proper difference of latitude.

Then from the merid. parts of	50° 00′	3474.5
subtract those of -	17 40	1057.2
and there remains - - -		2397.3

the meridional or enlarged difference of longitude.

Geometrically. Draw the line AC, fig. 12, representing the meridian of the Lizard at A; and set off from A, upon that line, AE equal to 1940 (from any scale of equal parts) the proper difference of latitude, also AC equal to 2397.3 (from the same scale) the meridional or enlarged difference of latitude. Upon the point C raise CB perpendicular to AC, and make CB equal to 4246, the minutes of difference of longitude.

Join AB, and through E draw ED parallel to BC: so the case is constructed; and AD applied to the same scale of equal parts the other legs were taken from, will give the direct distance, and the angle EAD measured by the line of chords will give the course.

By Calculation.

For the angle of the course EAD, it will be, (by rectangular trigonometry,)

AC : CB : : R : T. BAC,

i. e. As the merid. diff. of lat.	2397.3	3.37970
is to the difference of long.	4246.0	3.62798
so is radius - - - -		10.00000
to the tang. of the direct course	60° 33′	10.34828

which, because Port Royal is southward of the Lizard, and the difference of longitude westerly, will be south 60° 33′ west, or SW*b*W ½ west nearly.

Then for the distance AD, it will be (by rectangular trigonometry),

R : AE : : Sec. A : AD,

i. e. As the radius - -		10.00000
is to the proper diff. of lat.	1940	3.28780
so is the secant of the course	60° 33′	10.30833
to the distance	3945.6	3.59613

consequently the direct course and distance between the Lizard and Port Royal in Jamaica, is south 60° 33′ 3945.6 miles.

Case III. Course and distance sailed, given; to find difference of latitude, and difference of longitude.

Example. Suppose a ship from the Lizard in the latitude of 50° 0′ north, sails south 35° 40′ west 156 miles: required the latitude come to, and how much she has altered her longitude.

Geometrically. 1. Draw the line BK (fig. 13), representing the meridian of the Lizard at B; from B draw the line BM, making with BK an angle equal to 35° 40′; and upon this line set off BM equal to 56 the given distance, and from M let fall the perpendicular MK upon BK.

Then for BK the proper difference of latitude, it will be, (by rectangular trigonometry,)

R : MB : : S. BMK : BK,

i. e. As radius - - -		10.00000
is to the distance	156	2.19312
so is the co-sine of the course	35° 40′	9.90978
to the proper diff. of lat.	127	2.10290

equal to 2° 7′; and since the ship is sailing from a north latitude towards the south, therefore the latitude come to will be 47° 53′ north. Hence the meridional difference of latitude will be 193.4.

2. Produce BK to D, till BD is equal to 193.4; through D draw DL parallel to MK, meeting BM produced in L; then DL will be the difference of longitude: to find which by calculation, it will be, (by rectangular trigonometry,)

R : BD : : T. LBD : DL,

i. e. As radius - -		10.00000
is to the meridional diff. of lat.	193.4	2.28646
so is the tang. of the course	35° 40′	9.85594
to minutes of diff. of long.	138.8	2.14240

equal to 2° 18′ 48″, the difference of longitude the ship has made westerly.

Case IV. Given course and both latitudes, viz. the latitude sailed from, and the latitude come to; to find the distance sailed, and the difference of longitude.

Example. Suppose a ship in the latitude of 50° 20′ north, sails south 33° 45′ east, until by observation she is found to be in the latitude of 51° 45′ north: required the distance sailed, and the difference of longitude.

Geometrically. Draw AB (fig 14), to represent the meridian of a ship in the first latitude; and set off from A to B 155 the minutes of the proper difference of latitude, also AG equal to 257.9 the minutes of the enlarged difference of latitude. Through B and G, draw the lines BC and GK perpendicular to AG; also draw AK, making with AG an angle of 33° 45′, which will meet the two former lines in the points C and K; so the case is constructed, and AC and GK may be found from the line of equal parts: to find which,

By Calculation;

First, For the difference of longitude, it will be, (by rectangular trigonometry,)

R : AG : : T. GAK : GK,

i. e. As radius - -		10.00000
is to the enlarged diff. of lat.	257.2	2:41145
so is the tang. of the course	33° 45′	9.84289
to min. of diff. of longitude	172.3	2.23634

equal to 2° 52′ 18″, the difference of longitude the ship has made easterly.

This might also have been found, by first finding the departure BC (by Case 2. of Plane Sailing), and then it would be AB : BC : : AG : GK, the difference of longitude required.

Then, for the direct distance AC, it will be, (by rectangular trigonometry,)

R : AB : : Sec. A : AC,

i. e. As radius - -		10.00000
is to the proper diff. of lat.	155	2.19033
so is the secant of the course	33° 45′	10.08015
to the direct distance	186.4	2.27048

consequently the ship has sailed south 33′ 45° east 186.4 miles, and has differed her longitude 2° 52′ 18″ easterly.

Case V. Both latitudes and distances sailed, given; to find the direct course, and difference of longitude.

Example. Suppose a ship from the latitude of 45° 26′ north, sails between north and east 195 miles, and then by observation she is found to be in the latitude of 48° 6′ north: required the direct course, and difference of longitude.

Geometrically. Draw AB (fig. 15), equal to 160, the proper difference of latitude, and from the point B raise the perpendicular BD; then take 195 in your compasses, and setting one foot of them in A, with the other cross the line BD in D. Produce AB, till AC is equal to 233.6 the enlarged difference of latitude. Through C draw CK parallel to BD, meeting AD produced in K: so the case is constructed; and the angle A may be measured by the line of chords, and CK by the line of equal parts: to find which,

By Calculation;

First, For the angle of the course BAD, it will be, (by rectangular trigonometry.)

AB : R : : AD : Sec. A.

i. e. As the proper diff. of lat.	160	2.20412
is to radius - - -		10.00000
so is the distance -	195	2.29003
to the secant of the course	34° 52′	10.08591

which, because the ship is sailing between north and east, will be north 34° 52′ east, or NE*b*N 1° 7′ easterly.

Then, for the difference of longitude, it will be, (by rectangular trigonometry,)

R : AC : : T. A : CK,

i. e. As radius - -		10.00000
is to the merid. diff. of lat.	233.6	2.36847
so is the tang. of the course	34° 52′	9.84307
to min. of diff. of longitude	162.8	2.21154

equal to 2° 42′ 48″, the difference of longitude easterly.

Case VI. One latitude, course, and difference of longitude, given; to find the other latitude and distance sailed.

Example. Suppose a ship from the latitude of 48° 50′ north, sails south 34° 40′ west, till her difference of longitude is 2° 42′: required the latitude come to, and the distance sailed.

Geometrically. 1. Draw AE (fig. 16), to represent the meridian of the ship in the first latitude, and make the angle EAC equal to 34° 40′, the angle of the course; then draw FC parallel to AE, at the distance of 164 the minutes of difference of longitude, which will meet AC in the point C. From C let fall upon AE the perpendicular CE; then AE will be the enlarged difference of latitude. To find which, by calculation, it will be, (by rectangular trigonometry,)

T. A : R : : CE : AE,

i. e. As the tang. of the course	34° 40′	9.83984
is to the radius - -		10.00000
so is min. of diff. longitude	164	2.21484
to the enlarged diff. of latitude	237.2	2.37500

and because the ship is sailing from a north latitude southerly, therefore

From the merid. parts of the latitude sailed from	48° 50′	3366.9
take the merid. difference of latitude		237.2
and there remains - -		3129.7

the meridional parts of the latitude come to, viz. 46° 09′.

Hence, for the proper difference of latitude,

From the latitude sailed from	48° 50′ N
take the latitude come to	46 09 N
and there remains - -	2 41

equal to 161, the minutes of difference of latitude.

2. Set off upon AE the length AD equal to 161 the proper difference of latitude, and through D draw DB parallel to CE: then AB will be the direct distance. To find which, by calculation, it will be, (by rectangular trigonometry,)

R : AD : : Sec. A : AB.

i. e. As radius - -		10.00000
is to the proper diff. of lat.	161	2.20683
so is the secant of the course	34° 40′	10.08488
to the direct distance -	195.8	2.29171

Case VII. One latitude, course, and departure, given; to find the other latitude, distance sailed, and difference of longitude.

Example. Suppose a ship sails from the latitude of 54, 36′ north, south 42° 33′ east, until she has made of departure 116 miles: required the latitude she is in, her direct distance sailed, and how much she has altered her longitude.

Geometrically. 1. Having drawn the meridian AB (fig. 17), make the angle BAD equal to 42° 33′. Draw FD parallel to AB at the distance of 116, which will meet AD in D. Let fall upon AB the perpendicular DB. Then AB will be the proper difference of latitude, and AD the direct distance: to find which by calculation, first, for the distance AD it will be, (by rectangular trigonometry,)

S. A : BD : : R : AD.

i. e. As the sine of the course	42° 33′	9.83010
is to the departure -	116	2.06446
so is radius - - -		10.00000
to the direct distance	171.5	2.23436

Then, for the proper difference of latitude, it will be, (by rectangular trigonometry,)

T. A : BD :: R : AB.

i. e. As the tang. of the course	42° 33′	9.96281
is to the departure -	116	2.06446
so is radius - - -		10.00000
to the proper diff. of latitude	126.4	2.10165

equal to 2° 6′: consequently the ship has come to the latitude of 52° 30′ north; and so the meridional difference of lititude will be 212.2.

2. Produce AB to E, till AE be equal to 212.2; and through E draw EC parallel to BD, meeting AD produced in C; then EC will be the difference of longitude; to find which by calculation, it will be, (by rectangular trigonometry,)

R : AE :: T. A : EC.

i. e. As radius - -		10.00000
is to the merid. diff. of lat.	212.2	2.32675
so is the tang. of the course	42° 33′	9.96281
to the min. of diff. of long.	194.3	2.28956

equal to 3° 14′ 48″, the difference of longitude easterly.

This might have been found otherwise, thus: because the triangles ACE, ADB, are similar; therefore it will be,

AB : BD :: AE : EC.

i. e. As the proper diff. of lat.	126.4	2.10165
is to the departure -	116	2.06446
so is the enlarged diff. of lat.	212·2	2.32675
to min. of diff. of longitude	194.8	2.28956

Case VIII. Both latitudes and departure given; to find course, distance, and difference of longitude.

Example. Suppose a ship from the latitude of 46° 20′ N. sails between south and west, till she has made of departure 126.4 miles; and is then found by observation to be in the latitude of 43° 35′ north: required the course and distance sailed, and difference of longitude.

Geometrically. Draw AK (fig. 18), to represent the meridian of the ship in her first latitude; set off upon it AC, equal to 165, the proper difference of latitude. Draw BC perpendicular to AC, equal to 126.4 the departure, and join AB. Set off from A, AK equal to 233.3, the enlarged difference of latitude; and through K draw KD parallel to BC, meeting AB produced in D; so the case is constructed, and DK will be the difference of longitude, AB the distance, and the angle A the course; to find which,

By Calculation;

First, For DK the difference of longitude, it will be,

AC : CB :: AK : KD.

i. e. As the proper diff. of lat.	165	2.21748
is to the departure -	126.4	2.10175
so is the enlarged diff. of lat.	233.3	2.36791
to min. of diff. of longitude	178.7	2.25218

equal to 2° 58′ 42″ the difference of longitude westerly.

Then, for the course it will be, (by rectangular trigonometry,)

AC : BC :: R : T. A.

i. e. As the proper diff. of lat.	165	2.21748
is to the departure -	446.1	2.10175
so is radius - - -		10.00000
to the tang. of the course	37° 27′	9.88427

which, because the ship sails between south and west, will be south 37° 27′ west, or SW*b*S 6° 30′ westerly.

Lastly, For the distance AB, it will be, (by rectangular trigonometry,)

S, A : BC : : R : AB.

i. e, As the sine of the course	37° 27′	9.78395
is to the departure -	126.4	2.10175
so is radius - - -		10.00000
to the direct distance -	207.9	2.31780

Case IX. One latitude, distance sailed; and departure, given; to find the other latitude, difference of longitude, and course.

Example. Suppose a ship in the latitude of 48° 33′ north, sails between south and east 138 miles, and has then made of departure 112.6: required the latitude come to, the direct course, and difference of longitude.

Geometrically. 1. Draw BD (fig. 19) for the meridian of the ship at B; and parallel to it draw FE, at the distance of 112.6, the departure. Take 138, the distance, in your compasses, and fixing one point of them in B, with the other cross the line FE in the point E; then join B and E, and from E let fall upon BD the perpendicular ED; so BD will be the proper difference of latitude, and the angle B will be the course; to find which by calculation,

First, For the course it will be, (by rectangular trigonometry,)

BE : R : : DE : S. B.

i. e. As the distance -	138	2.13988
is to radius - - -		10.00000
so is the departure -	112.6	2.05154
to the sine of the course	54° 41′	9.91166

which, because the ship sails between south and east, will be south 54° 41′ east, or SE 0° 41′ easterly.

Then, for the difference of latitude, it will be, (by rectangular trigonometry,)

R : BE : : Co. S. B : BD.

i. e. As radius - -		10.00000
is to the distance -	138	2.13988
so is the co-sine of the course	54° 41′	9.76200
to the difference of latitude	79.8	1.90188

equal to 1° 19′. Consequently the ship has come to the latitude of 47° 13′. Hence the meridional difference of latitude will be 117.7.

2dly. Produce B to A, till BA is equal to 117.7; and through A draw AC parallel to DE, meeting BE produced in C; then AC will be the difference of longitude; to find which by calculation, it will be,

BD : DE : : BA : AC.

i. e. As the proper diff. of lat.	79.8	1.90180
is to the departure -	112.6	2.05154
so is the enlarged diff. of lat.	117.7	2.07078
to the diff. of longitude	166.1	2.22044

equal to 2° 46′ 06″, the difference of longitude easterly.

Having shown under the article Maps how to construct a Mercator's chart, we shall now proceed to point out its several uses.

Prob I. Let it be required to lay down a place upon the chart, its latitude, and the difference of longitude between it and some known place upon the chart being given.

Example. Let the known place be the Lizard, lying on the parallel of 50° 00′ north, and the place to be laid down St. Katherine's on the east coast of America, differing in longitude from the Lizard 42° 36′, lying so much to the westward of it.

Let L represent the Lizard on the chart, (fig. 20,)

lying on the parallel of 50° 00′ north, its meridian. Set off AE from E upon the equator EQ 42° 36′, towards Q, which will reach from E to F. Through F draw the meridian FG, and this will be the meridian of St. Katharine's; then set off from Q to H upon the graduated meridian QB, 28 degrees; and through H draw the parallel of latitude HM, which will meet the former meridian in K, the place upon the chart required.

Prob. II. Given two places upon the chart, to find their difference of latitude and difference of longitude.

Through the two places draw parallels of latitude; then the distance between these parallels, numbered in degrees and minutes upon the graduated meridian, will be the difference of latitude required; and through the two places drawing meridians, the distance between these, counted in degrees and minutes on the equator, or any graduated parallel, will be the difference of longitude required.

Prob. III. To find the bearing of one place from another, upon the chart.

Example. Required the bearing of St. Katherine's at K, from the Lizard at L.

Draw the meridian of the Lizard AE, and join K and L with the right line KL; then, by the line of chords, measuring the angle KLE, and with that entering the tables, we shall have the thing required.

This may also be done, by having compasses drawn on the chart (suppose at two of its corners); then lay the edge of a ruler over the two places, and let fall a perpendicular, or take the nearest distance from the centre of the compass next the first place, to the ruler's edge; then, with this distance in your compasses, slide them along by the ruler's edge, keeping one foot of them close to the ruler, and the other as near as you can judge perpendicular to it, which will describe the rhumb requred.

Prob. IV. To find the distance between two given places upon the chart.

This problem admits of four cases, according to the situation of the two places with respect to one another.

Case I. When the given places lie both upon the equator. In this case their distance is found by converting the degrees of difference of longitude intercepted between them into minutes.

Case II. When the two places lie both on the same meridian.

Draw the parallels of those places; and the degrees upon the graduated meridian, intercepted between those parallels, reduced to minutes, give the distance required.

Case III. When the two places lie on the same parallel.

Example. Required to find the distance between the points K and N, both lying on the parallel of 28° 00′ north. Take from your scale the chord of 60°, or radius, in your compasses, and with that extent on KN as a base make the isosceles triangle KPN: then take from the line of sines the co-sine of the latitude, or sine of 72° and set that off from P to S and T. Join S and T with the right line ST, and that applied to the graduated equator will give the degrees and minutes upon it equal to the distance; which, converted into minutes, will be the distance required.

The reason of this is evident from the method of Parallel Sailing; for it has been there demonstrated, that radius is to the co-sine of any parallel, as the length of any arch on the equator, to the length of the same arch on that parallel. Now, in this chart KN is the distance of the meridians of the two places K and N upon the equator; and since, in the triangle PNK, ST is the parallel to KN, therefore PN : PT : : NK : TS. Consequently TS will be the distance of the two places K and N upon the parallel of 28.

If the parallel the two places lie on is not far from the equator, and they not far asunder; then their distance may be found thus: Take the distance between them in your compasses and apply that to the graduated meridian, so that one foot may be as many minutes above as the other is below the given parallel; and the degrees and minutes intercepted, reduced to minutes, will give the distance.

Or it may also be found thus: Take the length of a degree on the meridian at the given parallel, and turn that over on the parallel from the one place to the other, as oft as you can; then, as often as that extent is contained between the places, so many times 60 miles will be contained in the distance between them.

Case IV. When the places differ both in longitude and latitude.

Example. Suppose it was required to find the distance between the two places *a* and *e* upon the chart. By Prob. II. find the difference of latitude between them; and take that in your compasses from the graduated equator, which set off on the meridian of *a*, from *a* to *b*; then through *b* draw *bc* parallel to *de*; and taking *ac* in your compasses, apply it to the graduated equator, and it will show the degrees and minutes contained in the distance required, which multiplied by 60 will give the miles of distance.

The reason of this is evident; for it is plain *ad* is the enlarged difference of latitude, and *ab* the proper; consequently *ae* is the enlarged distance, and *ac* the proper.

Prob. V. To lay down a place upon the chart, its latitude and bearing from some known place upon the chart being known; or, (which is the same) having the course and difference of latitude that a ship has made, to lay down the running of the ship, and find her place upon the chart.

Example. A ship from the Lizard in the latitude of 50° 00′ north, sails SSW till she has differed her latitude 36° 40′: required her place upon the chart.

Count from the Lizard at L, on the graduated meridian downwards, (because the course is southerly) 36° 40′ to *g*; through which draw a parallel of latitude, which will be the parallel the ship is in; then from L draw a SSW line L*f*, cutting the former parallel in *f*, and this will be the ship's place upon the chart.

Prob. VI. One latitude, course, and distance sailed, given; to lay down the running of the ship, and find her place upon the chart.

Example. Suppose a ship at *a* in the latitude of 20° 00′ north, sails north 37° 20′, east 191 miles: required the ship's place upon the chart.

Having drawn the meridian and parallel of the place *a*, set off the rhumb-line *ae*, making with *ab* an angle of 37° 20′; and upon it set off 191 from *a* to *c*; through *c* draw the parallel *ch*; and taking *ab* in your compasses, apply it to the graduated equator, and observe the number of degrees it contains; then count the same number

of degrees on the graduated meridian from C to *h*, and through *h* draw the parallel *he*, which will cut *ac* produced in the point *e*, the ship's place required.

Prob. VII. Both latitudes and distance sailed given; to find the ship's place upon the chart.

Example. Suppose a ship sails from *a*, in the latitude of 20° 00′ north, between north and east 191 miles, and is then in the latitude of 45° 00′ north: required the ship's place upon the chart.

Draw *de* the parallel of 45°, and set off upon the meridian of *a* upwards, *ab* equal to the proper difference of latitude taken from the equator or graduated parallel. Through *b* draw *bc* parallel to *de;* then, with 191 in your compasses, fixing one foot of them in *a*, with the other cross *bc* in *c*. Join *a* in *c* with the right line *ac;* which produced will meet *de* in *e*, the ship's place required.

Prob. VIII. One latitude, course, and difference of longitude, given; to find the ship's place upon the chart.

Example. Suppose a ship from the Lizard in the latitude of 50° 00′ north, sails SW*b*W, till her difference of longitude is 42° 36′; required the ship's place upon the chart.

Having drawn AE the meridian of the Lizard at L, count from E to F upon the equator 42° 36′; and through F draw the meridian EG; then from L draw the SW*b*W like LK, and where this meets FG, as at K, will be the ship's place required.

Prob. IX. One latitude, course, and departure, given; to find the ship's place upon the chart.

Example. Suppose a ship at *a* in the latitude of 20° 00′ north, sails north 37° 20′ east, till she has made of departure 116 miles: required the ship's place upon the chart.

Having drawn the meridian of *a*, at the distance of 116 draw parallel to it the meridian *kl*. Draw the rhumb-line *ac* which will meet *kl* in some point *c;* then through *c* draw the parallel *cb*, and *ab* will be the proper difference of latitude, and *bc* the departure. Take *ab* in your compasses, and apply it to the equator or graduated parallel; then observe the number of degrees it contains, and count so many on the graduated meridian from C upwards to *h*. Through *h* draw the parallel *he*, which will meet *ac* produced in some point as *e*, which is the ship's place upon the chart.

Prob. X. One latitude, distance, and departure, given; to find the ship's place upon the chart.

Example. Suppose a ship at *a* in the latitude of 20° 00′ north, sails 191 miles between north and east, and then is found to have made of departure 116 miles: required the ship's place upon the chart.

Having drawn the meridian and parallel of the place *a*, set off upon the parallel *am* equal to 116, and through *m* draw the meridian *kl*. Take the given distance 191 in your compasses; setting one foot of them in *a*, with the other cross *kl* in *c*. Join *ac*, and through *c* draw the parallel *cb;* so *ch* will be the departure, and *ab* the proper difference of latitude; then proceeding with this as in the foregoing problem, you will find the ship's place to be *e*.

Prob. XI. The latitude sailed from, difference of latitude, and departure, given; to find the ship's place upon the chart.

Example. Suppose a ship from *a* in the latitude of 20° 00′ north, sails between north and east, till she is in the latitude of 45° 00′ north, and is then found to have made of departure 116 miles: required the ship's place upon the chart.

Having drawn the meridian of *a*, set off upon it, from *a* to *b*, 25 degrees, (taken from the equator or graduated parallel) the proper difference of latitude; then through *b* draw the parallel *bc*, and make *bc* aqual to 116 the departure, and join *ac*. Count from the parallel of *a* on the graduated meridian upwards to *d* 25 degrees, and through *d* draw the parallel *de*, which will meet *ac* produced in some point *e*, and this will be the place of the ship required.

In the article of Plane Sailing, it is evident that the terms meridional distance, departure, and difference of longitude, were synonimous, constantly signifying the same thing; which evidently followed from the supposition of the earth's surface being projected on a plane in which the meridians were made parallel, and the degrees of latitude equal to one another and to those of the equator. But since it has been demonstrated, that if, in the projection of the earth's surface upon a plane, the meridians are made parallel, the degrees of latitude must be unequal, still increasing the nearer they come to the pole; it follows, that these terms must denote lines really different from one another.

Of Oblique Sailing. The questions that may be proposed on this head being innumerable, we shall only give one as a specimen.

Coasting along the shore, I saw a cape bear from me NNE: then I stood away NW*b*W 20 miles, and I observed the same cape to bear from me NE*b*E: required the distance of the ship from the cape at each station.

Geometrically. Draw the circle NW SE (figure 21.) to represent the compass, NS the meridian, and WE the east and west line, and let C be the place of the ship in her first station; then from C set off upon the NW*b*W line, CA 20 miles, and A will be the place of the ship in her second station.

From C draw the NNE line CB, and from A draw AB parallel to the NE*b*E line CD, which will meet CB in B, the place of the cape, and CB will be the distance of it from the ship in its first station, and AB the distance in the second: to find which,

By Calculation;

In the triangle ABC are given AC, equal to 20 miles; the angle ACB, equal to 78° 45′, the distance between the NNE and NW*b*W lines; also the angle ABC equal to BCD, equal to 33° 45′, the distance between the NNE and NE*b*E lines; and consequently the angle A, equal to 67° 30′.

Hence, for CB, the distance of the cape from the ship in her first station, it will be, (by oblique trigonometry,)

S. ABC : AC :: S. BAC : CB.

i. e. As the sine of the angle B	33° 45′	9.74473
is to the distance run AC	20 —	1.30163
so is the sine of BAC -	67 30	9.96562
to C B - - -	33. 26	1.52191

the distance of the cape from the ship at the first station. Then for AB, it will be, (by oblique trigonometry,)

S. ABC : AC :: S. ACB : AB.

i. e. As the sine of B -	33° 45′	9.74474
is to AC - -	20 —	1.30103
so is the sine of C -	78 45	9.99157
to AB - - -	35.31	1.54786

the distance of the ship from the cape at her second station.

Of the Log-line and Compass. The method commonly made use of for measuring a ship's way at sea, or how far she runs in a given space of time, is by the log-line and half-minute glass. See the article Log.

The log is generally about a quarter of an inch thick, and five or six inches from the angular point to the circumference. It is balanced by a thin plate of lead, nailed upon the arch, so as to swim perpendicularly in the water, with about $\frac{2}{3}$ impressed under the surface. The line is fastened to the log by means of two legs, one of which passes through a hole at the corner and is knotted on the opposite side; while the other leg is attached to the arch by a pin fixed in another hole, so as to draw out occasionally. By these legs the log is hung in equilibrio; and the line which is united to it, is divided into certain spaces, which are in proportion to an equal number of geographical miles, as a half-minute or quarter-minute is to an hour of time.

These spaces are called knots, because at the end of each of them there is a piece of twine with knots in it, inreeved between the strands of the line, which shows how many of these spaces or knots are run out during the half-minute. They commonly begin to be counted at the distance of about 10 fathoms or 60 feet from the log, so that the log when it is hove overboard may be out of the eddy of the ship's wake before they begin to count; and for the more ready discovery of this point of commencement, there is commonly fastened at it a piece of red rag.

The log being thus prepared, and hove overboard from the poop, and the line veered out by help of a reel that turns easily, and about which it is wound as fast as the log will carry it away, or rather as the ship sails from it, will show, according to the time of veering, how far the ship has run in a given time, and consequently her rate of sailing.

A degree of a meridian according to the exactest measures contains about 69.545 English miles: and each mile by the statute being 5280 feet, therefore a degree of the meridian will be about 7200 feet; whence the $\frac{1}{60}$ of that, viz. a minute or nautical mile, must contain 6120 standard feet; consequently, since $\frac{1}{2}$ is the $\frac{1}{120}$ part of an hour, and each knot is the same part of a nautical mile, it follows, that each knot will contain the $\frac{1}{120}$ of 6120 feet, viz. 51 feet.

Hence it is evident, that whatever number of knots the ship runs in half a minute, the same number of miles she will run in an hour, supposing her to run with the same degree of velocity during that time; and therefore it is the general way to heave the log every hour, to know her rate of sailing: but if the force or direction of the wind varies, and does not continue the same during the whole hour; or if there has been more sail set, or any sail handed, so that the ship has run swifter or slower in any part of the hour than she did at the time of heaving the log; then there must be an allowance made accordingly for it, and this must be according to the discretion of the artist.

Sometimes, when the ship is before the wind, and there is a great sea setting after her, it will bring home the log, and consequently the ship will sail faster than is given by the log. In this case it is usual, if there is a very great sea, to allow one mile in ten; and less in proportion, if the sea is not so great. But for the generality, the ship's way is really greater than that given by the log; and therefore, in order to have the reckoning rather before than behind the ship (which is the safest way), it will be proper to make the space on the log-line between knot and knot to consist of 50 feet instead of 51.

If the space between knot and knot on the log-line should happen to be too great in proportion to the half-minute glass, viz. greater than 50 feet, then the distance given by the log will be too short; and if that space is too small, then the distance run (given by the log) will be too great: therefore, to find the true distance in either case, having measured the distance between knot and knot, we have the following proportion, viz.

As the true distance, 50 feet, is to the measured distance; so are the miles of distance given by the log, to the true distance in miles that the ship has run.

Example I. Suppose a ship runs at the rate of $6\frac{1}{4}$ knots in half a minute; but measuring the space between knot and knot, I find it to be 56 feet: required the true distance in miles.

Making it, As 50 feet, are to 56 feet, so are 6.25 knots, to seven knots; I find that the true rate of sailing is 7 miles in the hour.

Example II. Suppose a ship runs at the rate of $6\frac{1}{2}$ knots in half a minute; but measuring the space between knot and knot, I find it to be only 44 feet: required the true rate the ship is sailing.

Making it, As 50 feet are to 44 feet, so are 6.5 knots to 5.72 knots, I find that the true rate of sailing is 5.72 miles in the hour.

Again, supposing the distance between knot and knot on the log-line to be exactly 50 feet, but that the glass is not 30 seconds; then, if the glass requires longer time than 30 seconds, the distance given will be too great, if estimated by allowing one mile for every knot run in the time the glass runs; and, on the contrary, if the glass requires less time to run than 30 seconds, it will give the distance sailed too small. Consequently, to find the true distance in either case, we must measure the time the glass requires to run out (by the method in the following article); then we have the following proportion, viz.

As the number of seconds the glass runs, is to half a minute, or 30 seconds; so is the distance given by the log, to the true distance.

Example I. Suppose a ship runs at the rate of $7\frac{1}{2}$ knots in the time the glass runs; but measuring the glass, I find it runs 34 seconds; required the true distance sailed.

Making it, As 34 seconds are to 30 seconds, so are 7.5 to 6.6; I find that the ship sails at the rate of 6.6 miles an hour.

Example. II. Suppose a ship runs at the rate of $6\frac{1}{4}$ knots; but measuring the glass, I find it runs only 25 seconds; required the true rate of sailing.

Make it, as 25 seconds are to 30 seconds, so are 6.5 knots to 7.8 knots; I find that the true rate of sailing is 7.8 miles an hour.

In order to know how many seconds the glass runs, you may try it by a watch or clock that vibrates seconds; but if neither of these is at hand, then take a line, and to the one end fastening a plummet, hang the other upon a nail or peg so that the distance from the peg to the centre of the plummet is $39\frac{1}{6}$ inches; then this put into motion will vibrate seconds; *i. e.* every time it passes the perpendicular, you are to count one second; consequently, by observing the number of vibrations that it makes during the time the glass is running, we know how many seconds the glass runs.

If there is an error both in the log-line and half-minute glass, viz. if the distance between knot and knot and the log-line is either greater or less than 50 feet, and the glass runs either more or less than 30 seconds; then the finding out the ship's true distance will be somewhat more complicate, and admit of three cases, viz.

Case I. If the glass runs more than 30 seconds, and the distance between knot and knot is less than 50 feet, then the distance given by the log-line, viz. by allowing 1 mile for each knot the ship sails while the glass is running, will always be greater than the true distance, since either of these errors gives the distance too great. Consequently, to find the true rate of sailing in this case, we must first find the distance on the supposition that the log-line only is wrong, and then with this we shall find the true distance.

Example. Suppose a ship is found to run at the rate of 6 knots; but examining the glass, I find it runs 35 seconds; and measuring the log-line, I find the distance between knot and knot to be but 46 feet: required the true distance run.

First, we have the following proportion, viz. As 50 feet : 46 : : 6 knots : 5.52 knots. Then, As 35 seconds: 30 seconds : : 5.52 knots : 4.73 knots. Consequently the true rate of sailing is 4.73 miles an hour.

Case II. If the glass is less than 30 seconds, and the space between knot and knot is more than 50 feet: then the distance given by the log will always be less than the true distance, since either of these errors lessens that true distance.

Example. Suppose a ship is found to run at the rate of 7 knots; but examining the glass, I find it runs only 25 seconds; and measuring the space between knot and knot on the log-line, I find it is 54 feet: required the true rate of sailing.

First, As 25 seconds : 30 seconds : : 7 knots : 8 knots. Then, as 50 feet : 54 feet : : 8.4 knots : 9.072 knots. Consequently the true rate of sailing is 9.072 miles an hour.

Case III. If the glass runs more than 30 seconds, and the space between knot and knot is greater than 50 feet; or if the glass runs less than 30 seconds, and the space between knot and knot is greater than 50 feet: then, since in either of these two cases the effects of the errors are contrary, it is plain the distance will sometimes be too great, and sometimes too little, according as the greater quantity of the error lies; as will be evident from the following examples:

Example I. Suppose a ship is found to run at the rate of $9\frac{1}{2}$ knots per glass; but examining the glass, it is found to run 36 seconds; and by measuring the space between knot and knot, it is found to be 58 feet; required the true rate of sailing.

First, As 50 feet : 58 feet : : 9.5 knots : 11.20 knots. Then, As 38 seconds : 30 seconds : : 11.02 knots : 8.7 knots. Consequently the ship's true rate of sailing is 8.7 miles an hour.

Example II. Suppose a ship runs at the rate of 6 knots per glass; but examining the glass, it is found to run only 20 seconds; and by measuring the log-line, the distance between knot and knot is found to be but 38 feet: required the true rate of sailing.

First, As 50 feet : 38 feet :: 6 knots : 4.56 knots. Then, As 20 seconds : 30 seconds : : 4.56 knots : 6.84 knots. Consequently the true rate of sailing is 6.83 miles an hour.

But if in this case it happens, that the time the glass takes to run, is to the distance between knot and knot, as 30, the seconds in half a minute, is to 50, the true distance between knot and knot; then it is plain, that whatever number of seconds the glass consists of, and whatever number of feet is contained between knot and knot, yet the distance given by the log-line will be the true distance in miles.

The meridian and prime vertical of any place cuts the horizon in four points, at 90 degrees distance from one another, viz. North, South, East, and West: that part of the meridian which extends itself from the place to the north point of the horizon is called the north line; that which tends to the south point of the horizon is called the south line; and that part of the prime vertical which extends towards the right hand of the observer when his face is turned to the north, is called the east-line; and lastly, that part of the prime vertical which tends towards the left hand is called the west line: the four points in which these lines meet the horizon are called the cardinal points.

In order to determine the course of the wind and to discover the various alterations or shiftings, each quadrant of the horizon, intercepted between the meridian and prime vertical, is usually divided into eight equal parts, and consequently the whole horizon into thirty-two; and the lines drawn from the place on which the observer stands, to the points of division in his horizon, are called rhumb-lines; the four principal of which are those described in the preceding paragraph, each of them having its name from the cardinal point in the horizon towards which it tends: the rest of the rhumb-lines have their names compounded of the principal lines on each side of them, as in the figure; and over whichsoever of these lines the course of the wind is directed, that wind takes its name accordingly. See MAGNETISM.

Hence it follows, that all rhumbs, except the four cardinals, must be curves or hemispherical lines, always tending towards the pole, and approaching it by infinite gyrations or turnings, but never falling into it. Thus let P, Plate XCIV. Miscel. fig. 172, be the pole, EQ an arch of the equator, PE, PA, &c. meridians, and EFG HKL any rhumb: then because the angles PEF, PFG, &c. are by the nature of the rhumb-line equal, it is evident that it will form a curve-line on the surface of the

globe always approaching the pole P, but never falling into it; for if it were possible for it to fall into the pole, then it would follow, that the same line could cut an infinite number of other lines at equal angles, in the same point; which is absurd.

Because there are 32 rhumbs or points in the compass equally distant from one another, therefore the angle contained between any two of them adjacent will be 11° 15′, viz. $\frac{1}{32}$ part of 360°; and so the angle contained between the meridian and the N*b*E will be 11° 15′ and between the meridian and the NNE will be 22° 30′; and so of the rest. See Table of the angles, &c. at the beginning of the article.

Concerning currents, and how to make proper allowances. 1. Currents are certain settings of the stream, by which all bodies (as ships, &c.) moving therein, are compelled to alter their course or velocity, or both; and submit to the motion impressed upon them by the current.

Case I. If the current sets just the course of the ship, *i. e.* moves on the same rhumb with it; then the motion of the ship is increased, by as much as is the drift or velocity of the current.

Example. Suppose a ship sails SE*b*S at the rate of 6 miles an hour, in a current that sets SE*b*S 2 miles an hour: required her true rate of sailing.

Here it is evident that the ship's true rate of sailing will be 8 miles an hour.

Case II. If the current sets directly against the ship's course, then the motion of the ship is lessened by as much as is the velocity of the current.

Example. Suppose a ship sails SSW at the rate of 10 miles an hour, in a current that sets NNE 6 miles an hour, required the ship's true rate of sailing.

Here it is evident, that the ship's true rate of sailing will be 4 miles an hour. Hence it is plain,

1. If the velocity of the current is less than the velocity of the ship, then the ship will get so much ahead as is the difference of these velocities.

2. If the velocity of the current is greater than that of the ship, then the ship will fall so much astern as is the difference of these velocities.

3. Lastly, if the velocity of the current is equal to that of the ship, then the ship will stand still, the one velocity destroying the other.

Case III. If the current thwarts the course of the ship, then it not only lessens or augments her velocity, but gives her a new direction, compounded of the course she steers and the setting of the current.

The method of keeping a journal at sea, and how to correct it; by making proper allowance for the lee-way, variation, &c. 1. Lee-way is the angle that the rhumb-line, upon which the ship endeavours to sail, makes with the rhumb she really sails upon. This is occasioned by the force of the wind or surge of the sea, when she lies to the windward, or is close hauled, which causes her to fall off and glide sideways from the point of the compass she capes at. Thus let NESW (fig. 22.) represent the compass; and suppose a ship at C capes at, or endeavours to sail upon, the rhumb C*a*; but by the force of the wind, and surge of the sea, she is obliged to fall off, and make her way good upon the rhumb C*b*; then the angle *a*C*b* is the lee-way; and if that angle is equal to one point, the ship is said to make one point lee-way; and if equal to two points, the ship is said to make two points lee-way, &c.

2. The quantity of this angle is very uncertain, because some ships, with the same quantity of sail, and with the same gale, will make more lee-way than others: it depending much upon the mould and trim of the ship, and the quantity of water that she draws. The common allowances that are generally made for the lee-way, are as follow:

(1.) If a ship is close hauled, has all her sails set, the water smooth, and a moderate gale of wind, she is then supposed to make little or no lee-way. (2.) If it blows so fresh as to cause the small sails to be handed, it is usual to allow one point. (3.) If it blows so hard that the top-sails must be close-reefed, then the common allowance is two points for lee-way. (4.) If one top-sail must be handed, then the ship is supposed to make between two and three points lee-way. (5.) When both top-sails must be handed, then the allowance is about four points for lee-way. (6.) If it blows so hard as to occasion the fore-course to be handed, the allowance is between 5½ and 6 points. (7.) When both main and fore-courses must be handed, then 6 or 6½ points are commonly allowed for lee-way. (8.) When the mizen is handed, and the ship is trying abull, she is then commonly allowed about 7 points for lee-way.

3. Though these rules are such as are generally made use of, yet since the lee-way depends much upon the mould and trim of the ship, it is evident that they cannot exactly serve to every ship; and therefore the best way is to find it by observation. Thus, let the ship's wake be set by a compass in the poop, and the opposite rhumb is the true course made good by the ship; then the difference between this and the course given by the compass in the binnacle, is the lee-way required. If the ship is within sight of land, then the lee-way may be exactly found by observing a point on the land which continues to bear the same way; and the distance between the point of the compass it lies upon, and the point the ship capes at, will be the lee-way. Thus, suppose a ship at C is lying up N*b*W (fig. 23.) towards A; but instead of keeping that course, she is carried on the NNE line CB, and consequently the point B continues to bear the same way from the ship; here it is evident that the angle ACB (or the distance between the N*b*W line that the ship capes at, and the NNE line that the ship really sails upon) will be the lee-way.

4. Having the course steered and the lee-way given, we may from thence find the true course by the following method, viz. Let your face be turned directly to the windward; and if the ship has her larboard tacks on board, count the lee-way from the course steered towards the right hand; but if the starboard tacks are on board, then count it from the course steered towards the left hand. Thus, suppose the wind at north, and the ship lies up within six points of the wind, with her larboard tacks on board, making one point lee-way; here it is plain that the course steered is ENE, and the true course E*b*N: also suppose the wind is at NNW, and the ship lies up within 6½ points of the wind, with her starboard tack on board, making 1½ point lee-way; it is evident that the true course, in this case, is WSW.

5. We have this general rule for finding the ship's true course, having the course steered and the variation given, viz. Let your face be turned towards the point of the compass upon which the ship is steered; and if the variation is easterly, count the quantity of it from the course steered towards the right hand, but if westerly towards the left hand; and the course thus found is the true course steered. Thus, suppose the course steered is N*b*E, and the variation one point easterly, then the true course steered will be NNE; also suppose the course steered is NE*b*E, and the variation one point westerly, then in this case the true course will be NE: and so of others.

Hence, by knowing the lee-way, variation, and course steered, we may from thence find the ship's true course; but if there is a current under foot, then that must be tried, and proper allowances made for it, as has been shown in the section concerning currents, from thence to find the true course.

6. After making all the proper allowances for finding the ship's true course, and making as just an estimate of the distance as we can; yet by reason of the many accidents that attend a ship in a day's running, such as different rates of sailing between the times of heaving the log, the want of due care at the helm by not keeping her steady but suffering her to yaw and fall off, sudden storms when no account can be kept, &c. the latitude by account frequently differs from the latitude by observation; and when that happens, it is evident there must be some error in the reckoning: to discover which, and where it lies, and also how to correct the reckoning, you may observe the following rules:

1st. If the ship sails near the meridian, or within 2 or $2\frac{1}{2}$ points thereof, then if the latitude by account disagrees with the latitude by observation, it is most likely that the error lies in the distance run; for it is plain, that in this case it will require a very sensible error in the course to make any considerable error in the difference of latitude, which cannot well happen if due care is taken at the helm, and proper allowances are made for the lee-way, variation, and currents. Consequently, if the course is pretty near the truth, and the error in the distance runs regularly through the whole, we may, from the latitude obtained by observation, correct the distance and departure by account, by the following analogies, viz.

As the difference of latitude by account
is to the true difference of latitude,
So is the departure by account
to the true departure,
And so is the direct distance by account
to the true direct distance.

The reason of this is plain; for let AB, fig. 24, denote the meridian of the ship at A: and suppose the ship sails upon the rhumb AE near the meridian, till by account she is found in C, and consequently her difference of latitude by account is AB; but by observation she is found in the parallel ED, and so her true difference of latitude is AD, her true distance AE, and her true departure DE; then, since the triangles ABC, ADE, are similar, it will be AB : AD :: BC : DE, and AB : AD :: AC : AE.

Example. Suppose a ship from the latitude of 45° 20′ north, after having sailed upon several courses near the meridian for 24 hours, her difference of latitude is computed to be upon the whole 95 miles southerly, and her departure 34 miles easterly: but by observation she is found to be in the latitude of 43° 10′ north, and consequently her true difference of latitude is 130 miles southerly; then for the true departure, it will be, As the difference of latitude by account 95, is to the true difference of latitude 130, so is the departure by account 34, to the true departure 46.52, and so is the distance by account 100.9, to the true distance 138.

2dly, If the courses are for the most part near the parallel of east and west, and the direct course is within $5\frac{1}{2}$ or 6 points of the meridian; then if the latitude by account differs from the observed latitude, it is most probable that the error lies in the course or distance, or perhaps both; for in this case it is evident, the departure by account will be very nearly true; and thence by the help of this, and the true difference of latitude, may the true course and direct distance be readily found by case 4. of plane sailing.

The form of the log-book and journal, together with an example of a day's work, are here subjoined.

To express the days of the week, we commonly use the characters by which the sun and planets are expressed, viz. ☉ denotes Sunday, ☽ Monday, ♂ Tuesday, ☿ Wednesday, ♃ Thursday, ♀ Friday, ♄ Saturday.

The Form of the Log-Book, with the Manner of working Days' Works at Sea.

THE LOG-BOOK.

H.	K.	$\frac{1}{2}$K	Courses.	Winds	Observations and Accidents. ☾ —— Day of ———
1					Fair weather: at four this afternoon I took my departure from the Lizard, in the latitude of 5° 00′ north, it bearing N N E, distance five leagues.
2				North	
3					
4					
5	7		SW*b*W	N*b*E	
6	7				
7	7	1			
8	7	1			
9	6				
10	6				
11	6		SSW	E*b*S	The gale increasing and being under all our sails.
12	6	1			
1	6	1			After three this morning, frequent showers with thick weather till near noon.
2	6	1	SW*b*W	NNE	
3	6	1			
4	7				
5		1			
6					
7	8				
8	8		SW	ENE	The variation I reckon to be one point westerly.
9	8	1			
10	9				
11	8	1	SW$\frac{1}{2}$W	NE*b*E	
12	8				

The Log-Book.

Courses Correct.	Dist.	Diff. Lat.		Diff. Long.	
		N.	S.	E.	W.
S SW	50		46.2		29.4
S *b* W	19		18.6		5.5
SW	49		29.7		45.5
SW *b* S	24.5		20.2		20.0
SW $\frac{1}{2}$ S	25.5		19.5		19.5
			144.2		125.0

Hence the ship, by account, has come to the latitude of 47° 46′ north, and has differed her longitude 2° 5′ westerly; so this day I have made my way good S. 31° 31′ W. distance 157.4 miles.

At noon the Lizard bore from me N. 31° 31′ E. distance 157.4 miles; and having observed the latitude, I found it agreed with the latitude by account.

We have under the article Longitude shown the method of finding the longitude at sea by means of time-keepers. For the method of doing the same by lunar observations, we refer to the Nautical Almanac, and the tables that accompany it.

NAUTILUS, in zoology, a genus belonging to the order of vermes testaceæ. The shell consists of one spiral valve, divided into several apartments by partitions. There are 17 species, chiefly distinguished by particularities in their shells.

The most remarkable division of the nautili is into the thin and thick-shelled kinds. The first is called nautilus papyraceus; and its shell is indeed no thicker than a piece of paper when out of the water. This species is not at all fastened to its shell; but there is an opinion, as old as the days of Pliny, that this creature creeps out of its shell, and goes on shore to feed. When this species is to sail, it expands two of its arms on high, and between these supports a membrane which it throws out on this occasion; this serves for its sail: and the two other arms it hangs out of its shell, to serve occasionally either as oars or as a steerage; but this last office is generally served by the tail. When the sea is calm, it is common to see numbers of these creatures diverting themselves in this manner; but as soon as a storm rises, or any thing gives them disturbance, they draw in their legs, and take in as much water as makes them specifically heavier than that in which they float; and they sink to the bottom. When they rise again, they void this water by a number of holes, of which their legs are full. The other nautilus, whose shell is thick, never quits that habitation. This shell is divided into 40 or more partitions, which grow smaller and smaller as they approach the extremity or centre of the shell; between every one of these cells and the adjoining ones, there is a communication by means of a hole in the centre of every one of the partitions. Through this hole there runs a pipe of the whole length of the shell. It is supposed by many, that by means of this pipe the fish occasionally passes from one cell to another; but this seems by no means probable, as the fish must undoubtedly be crushed to death by passing through it. It is much more likely that the fish always occupies the largest chamber in its shell; that is, that it lives in the cavity between the mouth and the first partition, and that it never removes out of this; but that all the apparatus of cells and a pipe of communication, which we so much admire, serves only to admit occasionally air or water into the shell, in such proportions as may serve the creature in its intentions of swimming.

Some authors call this shell the concha margaritifera: but this can be only on account of the fine colour on its inside, which is more beautiful than any other mother-of-pearl; for it has not been observed that this species of fish ever produced pearls. It must be observed, that the polypus is by no means to be confounded with the paper-shelled nautilus, notwithstanding the great resemblance in the arms and body of the inclosed fish; nor is the cornu ammonis, so frequently found fossil, to be confounded with the thick-shelled nautilus, though the concamerations and general structure of the shell are alike in both; for there are great and essential differences between all these genera.

NAZARITES, among the Jews, persons who either of themselves, or by their parents, were dedicated to the observation of Nazariteship. They were of two sorts, namely, such as were bound to this observance for only a short time, as a week or month; and those who were bound to it all their lives. All that we find peculiar in the latter's way of life is, that they were to abstain from wine and all intoxicating liquors, and never to shave or cut off the hairs of their heads. The first sort of Nazarites were moreover to avoid all defilement; and if they chanced to contract any pollution before the term was expired, they were obliged to begin afresh. Women as well as men might bind themselves to this vow.

NE ADMITTAS, in law, a writ directed to the bishop, at the suit of one that is patron of a church, where, on a quare impedit, &c. depending, he is doubtful that the bishop will collate his clerk, or admit the other's clerk, during the suit between them.

NEAT, or Net-weight, the weight of a commodity alone, clear of the cask, bag, case, or even filth.

NEBULOUS, *cloudy*, in astronomy, a term applied to certain of the fixed stars, which show a dim hazy light, being less than those of the sixth magnitude, and therefore scarce visible to the naked eye.

NECESSITY. The law charges no man with default where the act is compulsory, and not voluntary, and where there are not a consent and election; and therefore if either there is an impossibility for a man to do otherwise, or so great a perturbation of the judgment and reason as in presumption of law man's nature cannot overcome, such necessity carries a privilege in itself.

Necessity is of three sorts; necessity of conservation of life, necessity of obedience, and necessity of the act of God, or of a stranger.

And first, of conservation of life; if a man steals viands to satisfy his present hunger, this is no felony nor larceny.

The second necessity is of obedience; and therefore where baron and feme commit a felony the feme can neither be principal nor accessary, because the law intends her to have no will in regard of the subjection and obedience she owes her husband.

The third necessity is of the act of God, or of a stranger; as if a man is particular tenant for years of a house, and it should be overthrown by thunder, lightning, and tempest, in this case, he is excused of waste. Bac. Elem. 25, 26, 27.

NECK. See ANATOMY.

NECKERIA, a genus of the class and order cryptogamia musci, but little known.

NECTARIUM. See BOTANY, vol. i. p. 254.

NECTRIS, a genus of the hexandria digynia class and order: the calyx is one-leafed, six-parted, coloured; corolla none; styles permanent; caps. two; superior ovate, one-celled, many-seeded; there is one species, a native of Guiana.

NECYDALIS, a genus of insects belonging to the order of coleoptera. The feelers are setaceous; the elytra are shorter and narrower than the wings; the tail is simple. There are 11 species, chiefly distinguished by the size and figure of the elytra.

NEEDLE, a very common small instrument or utensil, made of steel, pointed at one end, and pierced at the other, used in sewing, embroidery, tapestry, &c. Needles make a very considerable article in commerce, though there is scarcely any commodity cheaper, the consumption of them being almost incredible. The sizes are from No. 1. the largest, to No. 25. the smallest. In the manufacture of needles, German and Hungarian steel are of most repute. In the making of them, the first thing is to pass the steel through a coal-fire, and under a hammer, to bring it out of its square figure into a cylindrical one. This done, it is drawn through a large hole of a wiredrawing-iron, and returned into the fire, and drawn through a second hole of the iron, smaller than the first, and thus successively, from hole to hole, till it has acquired the degree of fineness required for that species of needles, observing every time it is to be drawn that it is greased over with lard, to render it more manageable. The steel thus reduced to a fine wire, is cut in pieces of the length of the needles intended. These pieces are flatted at one end on the anvil, in order to form the head and eye: they are then put into the fire to soften them farther, and thence taken out and pierced at each extreme of the flat part on the anvil, by force of a puncheon of well-tempered steel; and laid on a leaden block to bring out, with another puncheon, the little piece of steel remaining in the eye. The corners are then filed off the square of the heads, and a little cavity filed on each side of the flat of the head; this done, the point is formed with a file, and the whole filed over; they are then laid to heat red-hot on a long flat narrow iron, crooked at one end, in a charcoal-fire, and when taken out, are thrown into a bason of cold water to harden. On this operation a good deal depends; too much heat burns them, and too little leaves them soft: the medium is learned by experience. When they are thus hardened, they are laid in an iron shovel on a fire, more or less brisk in proportion to the thickness of the needles; taking care to move them from time to time. This serves to temper them, and take off their brittleness: great care here too must be taken of the degree of heat. They are then straightened one after another with a hammer, the coldness of the water used in hardening them having twisted the greatest part of them. The next process is the polishing them. To do this they take twelve or fifteen thousand needles, and range them in little heaps against each other in a piece of new buckram sprinkled with emery-dust. The needles thus disposed, emery-dust is thrown over them, which is again sprinkled with oil of olives: at last the whole is made up into a roll, well bound at both ends. This roll is then laid on a polishing-table; and over it a thick plank loaden with stones, which two men work backwards and forwards a day and a half, or two days, successively; by which means the roll being continually agitated by the weight and motion of the plank over it, the needles withinside being rubbed against each other with oil and emery, are insensibly polished.

After polishing they are taken out, and the filth washed off them with hot water and soap; they are then wiped in hot bran, a little moistened, placed with the needles in a round box, and suspended in the air by a cord, which is kept stirring till the bran and needles are dry. The needles thus wiped in two or three different brans are taken out and put in wooden vessels, to have the good separated from those whose points or eyes have been broken, either in polishing or wiping; the points are then all turned the same way, and smoothed with an emery-stone turned with a wheel. This operation finishes them, and there remains nothing but to make them into packets of two hundred and fifty each.

NE EXEAT REGNO, is a writ to restrain a person from going out of the kingdom without the king's licence.

Within the realm, the king may command the attendance and service of all his liegemen; but he cannot send any man out of the realm, or even upon the public service, except seamen and soldiers, the nature of whose employment necessarily implies an exception. 1 Black. 138.

This writ is now mostly used where a suit is commenced in the court of chancery against a man, and he intending to defeat the other of his just demand, or to avoid the justice and equity of the court, is about to go beyond sea, or however, that the duty will be endangered if he goes.

If the writ is granted on behalf of a subject, and the party is taken, he either gives security by bond in such sum as is demanded, or he satisfies the court by answering (where the answer is not already in) or by affidavit, that he intends not to go out of the realm, and gives such reasonable security as the court directs, and then he is discharged. P. R. C. 252.

NEGLIGENCE, is where a person neglects or omits to do a thing which he is obliged by law to do. Thus where one has goods of another to keep till such a time, and he has a certain recompence or reward for the keeping, he shall stand charged for injury by negligence, &c.

NEPA, a genus of insects of the order hemeptera; the generic character is snout inflected; wings four, cross-complicate, coriaceous on the upper part; fore-feet cheliform, the rest formed for walking. This genus is aquatic, inhabiting stagnant waters, and preying on the smaller water-insects, &c. The largest species yet known, and which very far surpasses in size all the European animals of the genus, is the nepa grandis, which is a native of Surinam and other parts of South America, often measuring more than three inches in length. Its colour is a dull yellowish-brown, with a few darker shades

or variegations; the under wings are of a semitransparent white colour, and the abdomen is terminated by a short tubular process.

Nepa cinerea, or the common water-scorpion, is a very frequent inhabitant of stagnant waters in our own country, measuring about an inch in length, and appearing, when the wings are closed, entirely of a dull brown colour; but when the wings are expanded, the body appears of a bright red colour above, with a black longitudinal band down the middle; and the lower wings, which are of a fine transparent white, are decorated with red veins: from the tail proceeds a tubular bifid process or style, nearly of the length of the body, and which appears single on a general view, the two valves of which it consists being generally applied close to each other throughout their whole length. The animal is of slow motion, and is often found creeping about the shallow parts of ponds, &c. In the month of May it deposits its eggs on the soft surface of the mud at the bottom of the water; they are of a singular shape, resembling some of the crowned seeds, having an oval body, and upper part surrounded by seven radiating processes or curved spines; the young, when first hatched, are not more than the eighth of an inch in length. The water-scorpion flies only by night, when it wanders about the fields in the neighbourhood of its native waters. The larvæ and pupæ differ in appearance from the complete insect, in having only the rudiments of wings, and being of a paler or yellower colour. See Plate C. Nat. Hist fig 292.

Nepa cimicoides of Linnæus differs materially from the preceding species, and has at first view more the aspect of a notonecta than a nepa, the hind legs being formed for swimming briskly, and furnished with an edging of hairs on the inner side. This insect is less common than the preceding, but is found in similar situations.

Nepa linearis is an insect of a highly singular aspect, bearing a distant resemblance to some of the smaller insects of the genera mantis and phasma. It measures about an inch and a half from the tip of the snout to the beginning of the abdominal style or process, which is itself of equal length to the former part, and the whole animal is extremely slender in proportion to its length; the legs also are long and slender, and the chelæ or fore-legs much longer in proportion than those of the second species or nepa cinera; the colour of the animal is dull yellowish-brown; the back, when the wings are expanded, appearing of a brownish-red, and the under wings white and transparent. It inhabits the larger kind of stagnant waters, frequenting the shallower parts during the middle of the day, when it may be observed to prey on the smaller water-insects, &c. Its motions are singular, often striking out all its legs in a kind of starting manner at intervals, and continuing this exercise for a considerable time. The eggs are smaller than those of the nepa cinerea, of an oval shape, and furnished with two processes or bristles divaricating from the top of each. See Plate C. Nat. Hist. fig. 293.

There are 14 species.

NEPENTHES, a genus of the tetrandria order, in the gynandria class of plants, and in the natural method ranking among those of which the order is doubtful. The calyx is quadripartite; there is no corolla; the capsule is quadrilocular. There is one species, a plant of Ceylon.

NEPER'S RODS, or Bones, an instrument invented by J. Neper, baron of Merchiston, in Scotland, whereby the multiplication and division of large numbers are much facilitated.

Neper's rod, *the construction of.* Suppose the common table of multiplication to be made upon a plate of metal, ivory, or pasteboard, and then conceive the several columns (standing downwards from the digits on the head) to be cut asunder; and these are what we call Neper's rods for multiplication. But then there must be a good number of each; for as many times as any figure is in the multiplicand, so many rods of that species (*i. e.* with that figure on the top of it) must we have; though six rods of each species will be sufficient for any example in common affairs; there must be also as many rods of 0's.

But before we explain the way of using these rods, there is another thing to be known, viz. that the figures on every rod are written in an order different from that in the table. Thus, the little square space or division in which the several products of every column are written, is divided into two parts by a line across from the upper angle on the right to the lower on the left; and if the product is a digit, it is set in the lower division: if it has two places, the first is set in the lower, and the second in the upper division; but the spaces on the top are not divided. Also there is a rod of digits, not divided, which is called the index-rod; and of this we need but one single rod. See the figure of all the different rods, and the index, separate from one another, in plate XCIV. Miscel. fig. 174.

Neper's rod, *multiplication by.* First lay down the index-rod; then on the right of it set the rod whose top is the figure in the highest place of the multiplicand; next to this again set the rod whose top is next the figure of the multiplicand; and so on in order to the first figure. Then is your multiplicand tabulated for all the nine digits; for in the same line of squares standing against every figure of the index-rod, you have the product of that figure, and therefore you have no more to do than to transfer the products and sum them. But in taking out these products from the rods, the order in which the figures stand obliges you to a very easy and small addition; thus, begin to take out the figure in the lower part, or unit's place, of the square of the first rod on the right; add the figure in the upper part of this rod to that in the lower part of the next, and so on, which may be done as fast as you can look on them. To make this practice as clear as possible, take the following example.

Example: To multiply 4768 by 385. Having set the rods together for the number 4768, against 5 in the index I find this number, by adding according to the rule - - - - - - - 23840

Against 8 this number - - -	38144
Against 3 this number - -	14304
Total product	1835680

To make the use of the rods yet more regular and easy, they are kept in a flat square box, whose breadth is that of ten rods, and the length that of one rod, as thick

as to hold six (or as many as you please): the capacity of the box being divided into ten cells, for the different species of rods. When the rods are put up in the box (each species in its own cell distinguished by the first figure of the rod set before it on the face of the box near the top), as much of every rod stands without the box as shows the first figure of that rod; also upon one of the flat sides without and near the edge, upon the left hand the index-rod is fixed; and along the foot there is a small ledge, so that the rods when applied are laid upon this side, and supported by the ledge, which makes the practice very easy; but in case the multiplicand should have more than 9 places, the upper face of the box may be made broader. Some make the rods with four different faces and figures on each for different purposes.

NEPER'S RODS, *division by*. First tabulate your divisor; then you have it multiplied by all the digits, out of which you may choose such convenient divisors as will be next less to the figures in the dividend, and write the index answering in the quotient, and so continually till the work is done. Thus 2179788 divided by 6123, gives in the quotient 356.

Having tabulated the divisor, 6123, you see that 6123 cannot be had in 2179; therefore take five places, and on the rods find a number that is equal, or next less, to 21797, which is 18369; that is 3 times the divisor, wherefore set 3 in the quotient, and subtract 18369 from the figures above, and there will remain 3428; to which add 8, the next figure of the dividend, and seek again on the rods for it, or the next less, which you will find to be five times; therefore set 5 in the quotient, and subtract, 30615 from 34288, and there will remain 3673; to which add 8, the last figure in the dividend, and finding it to be just 6 times the divisor, set 6 in the quotient.

NEPETA, CATMINT, or NEP, a genus of the gymnospermia order, in the didynamia class of plants; and in the natural method ranking under the 42d order, verticillatæ. The under lip of the corolla has a small middle segment crenated; the margin of the throat is reflected; the stamina approach one another. There are 20 species; the most remarkable is the cataria, common nep, or catmint. This is a native of many parts of Britain, growing about hedges and in waste places. The plant has a bitter taste, and strong smell, not unlike pennyroyal. An infusion of this plant is reckoned a good cephalic and emmenagogue; being found very efficacious in chlorotic cases. Two ounces of the expressed juice may be given for a dose. It is called catmint, because cats are very fond of it, especially when it is withered; for then they will roll themselves on it, and tear it to pieces, chewing it in their mouths with great pleasure.

NEPHELIUM, a genus of the pentandria order, in the monœcia class of plants. The male calyx is quinquedentate; there is no corolla: the female calyx is quadrifid; there is no corolla. There are two germens and two styles on each: the fruit are two dry plumbs, muricated, and monospermous. There is one species, a herb of the East Indies.

NEPHRITIC WOOD, lignum nephriticum, a wood of a very dense and compact texture, and of a fine grain, brought us from New Spain, in small blocks, in its natural state, and covered with its bark. It is to be chosen of a pale colour, sound and firm, and such as has not lost its acrid taste; but the surest test of it is the infusing it in water; for a piece of it infused only half an hour in cold water, gives it a changeable colour, which is blue or yellow, as variously held to the light. If the phial it is in is held between the eye and the light, the tincture appears yellow; but if the eye is placed between the light and the phial, it appears blue.

This wood is a very good diuretic, and is said to be of great use with the Indians in all diseases of the kidneys and bladder, and in suppressions of urine from whatever cause. It is also commended in fevers and obstructions of the viscera. The way of taking it, among the Indians, is only an infusion in cold water.

NEPHRITIS. See MEDICINE.

NEREIS, in zoology, a genus of animals belonging to the order of vermes mollusca. The body is oblong, linear, and fitted for creeping; it is furnished with lateral pencilled tentacula. There are 11 species, of which the most remarkable are the five following: 1. The noctiluca, or noctilucous nereis, which inhabits almost every sea, and is one of the causes of the luminousness of the water. These creatures shine like glow-worms, but with a brighter splendour, so as at night to make the element appear as if on fire all around. Their bodies are so minute as to elude examination by the naked eye.

It is sometimes called nereis phosphorans; and is thus described by Griseline. The head is roundish and flat, and the mouth acuminated. The two horns or feelers are short and subulated. The eyes are prominent, and placed on each side of the head. The body is composed of about twenty-three segments or joints; which are much less nearer the tail than at the head. These segments on both sides the animal all end in a short conical apex, out of which proceeds a little bundle of hairs; from under these bundles the feet grow in the form of small flexile subulated figments destitute of any thing like claws. It is scarcely two lines long, and is quite pellucid, and its colour is that of water, green. They are found upon all kinds of marine plants; but they often leave them, and are found upon the surface of the water: they are frequent at all seasons, but especially in summer before stormy weather, when they are more agitated and more luminous. Their numbers, and wonderful agility, added to their pellucid and shining quality, do not a little contribute to their illuminating the sea, for myriads of those animalculæ may be contained in the portion of a small cup of sea-water. Innumerable quantities of them lodge in the cavities of the scales of fishes, and to them probably do the fishes owe their noctilucous quality.

2. Nereis lacustris, or bog nereis (fig. 2.) The body of the size of a hog's short bristle, transparent, articulated, and on either side at every articulation provided with a short setaceous foot; interiorly it seems to consist in a manner of oval-shaped articulations, and a back formed by two lines bent backwards. It inhabits marshes abounding in clay, where it remains under ground, pushing out its other extremity by reason of its continual motion. When taken out it twists itself up. Is frequent in Sweden.

3. Nereis cirrosa, or waving nereis. The body is red, lumbriciform, with sixty-five notches, furnished on both sides with two rows of bristles. At each side of the head

ten filaments, at the sides of the mouth many, twice as long as the former. It dwells in Norway, on rocks at the bottom of the sea. It vomits a red liquor, with which it tinges the water. See Plate C. Nat. Hist. fig. 294.

4. Nereis cæerulea, or blue nereis. It inhabits the ocean, where it destroys the serpulæ and teredines. Fig. 295.

5. Nereis gigantæa, or giant nereis, is a peculiar species of those large worms that make their way into decayed piles driven down into the sea, which they bore through and feed upon, whence they are called sea-worms, or nereis. From head to tail they are beset on either side with small tufts terminating in three points, which are like the fine hair-pencils used by painters, and composed of shining bristles of various colours. The upper part of the body in this worm is all over covered with small hairs. The rings of which it is formed are closely pressed together, and yield to the touch. The three rows of small tufts we have been describing, serve this nereis instead of feet, which it uses to go forwards as fishes do their fins. Fig. 296.

NERITA, a genus of verms testacea: the generic character is; animal a limax; shell univalve, spiral, gibbous, flattish at bottom; aperture semiorbicular or semilunar; pillarlip transversely truncate, flattish. There are about 80 species of this genus.

NERIUM, a genus of the monogynia order, in the pentandria class of plants, and in the natural method ranking under the 30th order, contortæ. There are two erect follicles; the seeds plumy; the tube of the corolla terminated by a lacerated crown. There are nine species, all of them natives of the warmer climates; the most remarkable of which are, 1. The oleander, South Sea rose; this is a beautiful shrub, cultivated in gardens on account of its flower, which are of a fine red, and in clusters, but of an indifferent smell; the whole plant is poisonous, and especially the bark of the roots. The double variety is beautiful, but it should be kept in a stove. 2. The antidysintericum, a native of Ceylon; the bark of which is an article of the materica medica, under the name of conessi. 3. The tinctorium, a new species, with beautiful blue flowers, discovered by Dr. Roxburgh at Madras. A decoction of the leaves, with an addition of lime-water, makes an indigo of fine quality. The whole plant in all the neriums is of a poisonous quality, in that respect resembling apocynum.

NERTERIA, a genus of the class and order tetrandria digynia: the corolla is funnel-shaped, four cleft; superior berry two-celled; seeds solitary. There is one species, an annual of New Zealand.

NERVES. See Anatomy.

NESTORIANS, a christian sect, the followers of Nestorius, bishop and patriarch of Constantinople; who, about the year 429, taught that there were two persons in Jesus Christ, the divine and the human, which are united, not hypostatically or substantially, but in a mystical manner: whence he concluded, that Mary was the mother of Christ, and not the mother of God. For this opinion Nestorius was condemned and deposed by the council of Ephesus; and the decree of this council was confirmed by the emperor Theodosius, who banished the bishop to a monastery.

NETTING, in a ship, a sort of grates made of small ropes, seized together with rope-yarn or twine, and fixed on the quarters and in the tops; they are sometimes stretched upon the ledges from the waste-trees to the roof-trees, from the top of the forecastle to the poop; and sometimes are laid in the waste of a ship to serve instead of gratings.

NETTLE. See Urtica.

Nettle, *dead*. See Lamium.

NEURADA, a genus of the decagynia order, in the decandria class of plants, and in the natural method ranking under the 13th order, succulentæ. The calyx is quinquepartite; there are five petals; the capsule inferior, decemlocular, decaspermous, and aculeated. There is only one species, the procumbens. The whole plant is white and woolly; and is a native of the warm climates, and found on dry parched grounds.

NEUTRAL SALTS, among chemists, a sort of salts neither acid nor alkaline, but partaking of the nature of both. See Acid, Alkali, Chemistry, &c.

NEUTRALIZATION. When two or more substances mutually destroy each other's properties, they are said to neutralize one another. Thus, in a proper combination of acid and alkaline substances, the acid and alkaline properties are destroyed.

NEWEL. See Architecture.

NEWT. See Lacerta.

NEWTONIAN PHILOSOPHY, the doctrine of the universe, or the properties, laws, affections, actions, forces, motions, &c. of bodies, both celestial and terrestrial, as delivered by Newton.

The chief parts of the Newtonian philosophy, as delivered by the author, except his Optical Discoveries, &c. are contained in his Principia, or Mathematical Principles of Natural Philosophy. He founds his system on the following definitions.

1. Quantity of matter is the measure of the same, arising from its density and bulk conjointly. Thus, air of a double density, in the same space, is double in quantity; in a double space, is quadruple in quantity; in a triple space, is sextuple in quantity, &c.

2. Quantity of motion is the measure of the same, arising from the velocity and quantity of matter conjunctly. This is evident, because the motion of the whole is the motion of all its parts; and therefore in a body double in quantity, with equal velocity, the motion is double, &c.

3. The vis insita, vis inertæ, or innate force of matter, is a power of resisting, by which every body, as much as in it lies, endeavours to persevere in its present state, whether it is of rest, or moving uniformly forward in a right line. This definition is proved to be just, by experience, from observing the difficulty with which any body is moved out of its place, upwards or obliquely; or even downwards, when acted on by a body endeavouring to urge it quicker than the velocity given it by gravity, and any how to change its state of motion or rest. And therefore this force is the same, whether the body has gravity or not; and a cannon-ball, void of gravity, if it could be, being discharged horizontally, will go the same distance in that direction, in the same time, as if it were endued with gravity.

4. An impressed force is an action exerted upon a body, in order to change its state, whether of rest or mo-

tion. This force consists in the action only; and remains no longer in the body when the action is over. For a body maintains every new state it acquires, by its vis inertiæ only.

5. A centripetal force is that by which bodies are drawn, impelled, or any way tend, towards a point, as to a centre. This may be considered of three kinds, absolute, accelerative, and motive.

6. The absolute quantity of a centripetal force is a measure of the same, proportional to the efficacy of the cause that urges it to the centre.

7. The accelerative quantity of a centripetal force, is the measure of the same proportional to the velocity which it generates in a given time.

8. The motive quantity of a centripetal force, is a measure of the same, proportional to the motion which it generates in a given time. This is always known by the quantity of force equal and contrary to it, that is just sufficient to hinder the descent of the body.

After these definitions, follow certain scholia, treating of the nature and distinctions of time, space, place, and motion, absolute, relative, apparent, true, real, &c. After which, the author proposes to show how we are to collect the true motions from their causes, effects, and apparent differences; and vice versa, how, from the motions, either true or apparent, we may come to the knowledge of their causes and effects. In order to this, he lays down the following axioms or laws of motion.

1st law. Every body perseveres in its state of rest, or of uniform motion in a right line; unless it is compelled to change that state by forces impressed upon it. Thus, "projectiles persevere in their motions, so far as they are not retarded by the resistance of the air, or impelled downwards by the force of gravity. A top, whose parts, by their cohesion, are perpetually drawn aside from rectilinear motions, does not cease its rotation otherwise than as it is retarded by the air. The greater bodies of the planets and comets, meeting with less resistance in more free spaces, preserve their motions, both progressive and circular, for a much longer time."

2d law. The alteration of motion is always proportional to the motive force impressed, and is made in the direction of the right line in which that force is impressed. Thus, if any force generates a certain quantity of motion, a double force will generate a double quantity, whether that force is impressed all at once or in successive moments.

3d law. To every action there is always opposed an equal re-action; or the mutual actions of two bodies upon each other, are always equal, and directed to contrary parts. Thus, whatever draws or presses another, is as much drawn or pressed by that other. If you press a stone with your finger, the finger is also pressed by the stone, &c.

From this axiom, or law, Newton deduces the following corollaries:

1. A body by two forces conjoined will describe the diagonal of a parallelogram, in the same time that it would describe the sides by those forces apart.

2. Hence is explained the composition of any one direct force out of any two oblique ones, viz. by making the two ablique forces the sides of a parallelogram, and the diagonal the direct one.

3. The quantity of motion, which is collected by taking the sum of the motions directed towards the same parts, and the difference of those that are directed to contrary parts, suffers no charge from the action of bodies among themselves; because the motion which one body loses is communicated to another.

4. The common centre of gravity of two or more bodies does not alter its state of motion or rest by the actions of the bodies among themselves; and therefore the common centre of gravity of all bodies, acting upon each other, (excluding external actions and impediments) is either at rest, or moves uniformly in a right line.

5. The motions of bodies included in a given space are the same among themselves, whether that space is at rest, or moves uniformly forward in a right line without any circular motion. The truth of this is evident from the experiment of a ship; where all motions are just the same, whether the ship is at rest, or proceeds uniformly forward in a straight line.

6. If bodies, any how moved among themselves, are urged in the direction of parallel lines by equal accelerative forces, they will all continue to move among themselves, after the same manner as if they had not been urged by such forces.

The mathematical part of the Newtonian Philosophy depends chiefly on the following lemmas, especially the first, containing the doctrine of prime and ultimate ratios.

Lem. 1. Quantities, and the ratios of quantities, which in any finite time converge continually to equality, and before the end of that time approach nearer the one to the other than by any given difference, become ultimately equal.

Lem. 2. shows, that in a space bounded by two right lines and a curve, if an infinite number of parallelograms are inscribed, all of equal breadth; then the ultimate ratio of the curve space, and the sum of the parallelograms, will be a ratio of equality.

Lem. 3. shows, that the same thing is true when the breadths of the parallelograms are unequal.

In the succeeding lemmas it is shown, in like manner, that the ultimate ratios of the sine, chord, and tangent, of arcs infinitely diminished, are ratios of equality; and therefore that in all our reasonings about these, we may safely use the one for the other: that the ultimate form of evanescent triangles, made by the arc, chord, or tangent, is that of similitude, and their ultimate ratio is that of equality; and hence, in reasonings about ultimate ratios, these triangles may safely be used one for another, whether they are made with the sine, the arc, or the tangent. He then demonstrates some properties of the ordinates of curvilinear figures, and shows that the spaces which a body describes by any finite force urging it, whether that force is determined and immutable, or continually varied, are to each other, in the very beginning of the motion, in the duplicate ratio of the forces; and lastly, having added some demonstrations concerning the evanescence of angles of contact, he proceeds to lay down the mathematical part of his system, which depends on the following theorems.

Theor. 1. The areas which revolving bodies describe by radii drawn to an immoveable centre of force, lie in the same immoveable planes, and are proportional to the times in which they are described. To this proposition

are annexed several corollaries respecting the velocities of bodies revolving by centripetal forces, the directions and proportions of their forces, &c. such as, that the velocity of such a revolving body is reciprocally as the perpendicular let fall from the centre of force upon the line touching the orbit in the place of the body, &c.

Theor. 2. Every body that moves in any curve line described in a plane, and by a radius drawn to a point either immoveable or moving forward with an uniform rectilinear motion, describes about that point areas proportional to the times, is urged by a centripetal force directed to that point. With corollaries relating to such motions in resisting mediums, and to the direction of the forces when the areas are not proportional to the times.

Theor. 3. Every body that, by a radius drawn to the centre of another body, any how moved, describes areas about that centre proportional to the times, is urged by a force compounded of the centripetal forces tending to that other body, and of the whole accelerative force by which that other body is impelled. With several corollaries.

Theor. 4. The centripetal forces of bodies which by equal motions describe different circles, tend to the centres of the same circles; and are one to the other as the squares of the arcs described in equal times, applied to the radii of the circles. With many corollaries relating to the velocities, times, periodic forces, &c. And, in a scholium, the author farther adds, moreover, by means of the foregoing proposition and its corollaries, we may discover the proportion of a centripetal force to any other known force, such as that of gravity. For if a body, by means of its gravity, revolves in a circle concentric to the earth, this gravity is the centripetal force of that body. But from the descent of heavy bodies, the time of one entire revolution, as well as the arc described in any given time, is given by a corollary to this proposition.

On these and such-like principles depends the Newtonian matematical philosophy. The author farther shows how to find the centre to which the forces impelling any body are directed, having the velocity of the body given; and finds that the centrifugal force is always as the versed sine of the nascent arc directly, and as the square of the time inversely; or directly as the square of the velocity, and inversely as the chord of the nascent arc. From these premises, he deduces the method of finding the centripetal force directed to any given point when the body revolves in a circle; and this, whether the central point is near hand, or at immense distance; so that all the lines drawn from it may be taken for parallels. And he shows the same thing with regard to bodies revolving in spirals, ellipses, hyperbolas, or parabolas. He shows also, having the figures of the orbits given, how to find the velocities and moving powers; and indeed resolves the most difficult problems relating to the celestial bodies with a surprising degree of mathematical skill. These problems and demonstrations are all contained in the first book of the Principia; but an account of them here would neither be generally understood, nor easily comprised in the limits of this work.

In the second book, Newton treats of the properties and motion of fluids, and their powers of resistance, with the motion of bodies through such resisting mediums, those resistances being in the ratio of any powers of the velocities; and the motions being either made in right lines or curves, or vibrating like pendulums.

On entering upon the third book of the Principia, Newton briefly recapitulates the contents of the two former books in these words: "In the preceding books I have laid down the principles of philosophy, principles not philosophical, but mathematical; such, to wit, as we may build our reasonings upon in philosophical inquiries. These principles are, the laws and conditions of certain motions, and powers or forces, which chiefly have respect to philosophy. But lest they should have appeared of themselves dry and barren, I have illustrated them here and there with some philosophical scholiums, giving an account of such things are of a more general nature, and which philosophy seems chiefly to be founded on; such as the density and the resistance of bodies, spaces void of all matter, and the motion of light and sounds. It remains, he adds, that from the same principles I now demonstrate the frame of the system of the world. Upon this subject I had indeed composed the third book in a popular method, that it might be read by many. But afterwards considering that such as had not sufficiently entered into the princples could not easily discern the strength of the consequences, nor lay aside the prejudices to which they had been many years accustomed; therefore to prevent the disputes which might be raised upon such accounts. I chose to reduce the substance of that book into the form of propositions, in the mathematical way, which should be read by those only who had first made themselves masters of the principles established in the preceding books."

As a necessary preliminary to this third part, Newton lays down rules for reasoning in natural philosophy.

The phenomena first considered are, 1. That the satellites of Jupiter, by radii drawn to his centre, describe areas proportional to the times of description; and that their periodic times, the fixed stars being at rest, are in the sesquiplicate ratio of their distances from that centre. 2. The same thing is likewise observed of the phenomena of Saturn. 3. The five primary planets, Mercury, Venus, Mars, Jupiter, Saturn, with their several orbits, encompass the sun. 4. The fixed stars being supposed at rest, the periodic times of the said five primary planets, and of the earth, about the sun, are in the sesquiplicate proportion of their mean distances from the sun. 5. The primary planets, by radii drawn to the earth, describe areas no ways proportional to the times; but the areas which they describe by radii drawn to the sun are proportional to the times of description. 6. The moon, by a radius drawn to the centre of the earth, describes an area proportional to the time of description. All which phenomena are clearly evinced by astronomical observations. The mathematical demonstrations are next applied by Newton in the following propositions.

Prop. 1. The forces by which the satellites of Jupiter are continually drawn off from rectilinear motions, and retained in their proper orbits, tend to the centre of that planet, and are reciprocally as the squares of the distances of those satellites from that centre.

Prop. 2. The same thing is true of the primary planets, with respect to the sun's centre.

Prop. 3. The same thing is also true of the moon, in respect of the earth's centre.

Prop. 4. The moon gravitates towards the earth; and by the force of gravity is continually drawn off from a rectilinear motion, and retained in her orbit.

Prop. 5. The same thing is true of all the other planets, both primary and secondary, each with respect to the centre of its motion.

Prop. 6. All bodies gravitate towards every planet, and the weights of bodies towards any one and the same planet, at equal distances from its centre, are proportional to the quantities of matter they contain.

Prop. 7. There is a power of gravity tending to all bodies, proportional to the several quantities of matter which they contain.

Prop. 8. In two spheres mutually gravitating each towards the other, if the matter in places on all sides, round about and equidistant from the centres, is similar, the weight of either sphere towards the other, will be reciprocally as the square of the distance between their centres. Hence are compared together the weights of bodies towards different planets; hence also are discovered the quantities of matter in the several planets; and hence likewise are found the densities from those planets.

Prop. 9. The force of gravity, in parts downwards from the surface of the planets towards their centres, decreases nearly in the proportions of the distances from those centres.

These, and many other propositions and corollaries, are proved or illustrated by a great variety of experiments, in all the great points of physical astronomy. See GRAVITY, GRAVITATION, &c.

NICANDRA, a genus of the monogynia order in the decandria class of plants, and in the natural method ranking under the 18th order, contortæ. The calyx is monophyllous and quadripartite; the corolla is monopetalous, tubulated, and parted into ten laciniæ; the fruit is an oval berry, which is grooved longitudinally, and contains many small angular seeds. Of this there is only one species, the amara, a native of Guiana. The leaves and stalks are bitter, and used by the natives as an emetic and purge.

NICHE. See ARCHITECTURE.

NICKEL, in mineralogy. There is found in different parts of Germany a heavy mineral of a reddish-brown colour, not unlike copper. When exposed to the air, it gradually loses its lustre, becomes at first brownish, and is at last covered with green spots. It was at first taken for an ore of copper; but as none of that metal can be extracted from it, the German miners give it the name of kupfernickel, or false copper. Hierne, who may be considered as the father of the Swedish chemists, is the first person who mentions this mineral. He gives a description of it in a book published by him in 1694 on the art of detecting metals. It was generally considered by mineralogists as an ore of copper, till it was examined by the celebrated Cronstedt. He concluded from his experiments, which were published in the Stockholm Transactions for 1751 and 1754, that it contained a new metal, to which he give the name of nickel.

This opinion was embraced by all the Swedes, and indeed by the greater number of chemical philosophers. Some, however, particularly Sage and Monnet, affirmed, that it contained no new metal, but merely a compound of various known metals, which could be separated from each other by the usual processes. These assertions induced Bergman to undertake a very laborious course of experiments, in order, if possible, to obtain nickel in a state of purity; for Cronstedt had not been able to separate a quantity of arsenic, cobalt, and iron, which adhered to it with much obstinacy. These experiments, which were published in 1775, fully confirmed the conclusions of Cronstedt.

Nickel, when perfectly pure, is of a fine white colour, resembling silver; and like that metal it leaves a white trace when rubbed upon the polished surface of a hard stone. It is rather softer than iron. Its specific gravity is 9. Its malleability, while cold, is rather greater than that of iron, but it cannot be heated without being oxidated, and in consequence rendered brittle. It is attracted by the magnet as strongly as iron. Like that metal, it may be converted into a magnet; and in that state points to the north when freely suspended, precisely as a common magnetic needle. It requires for fusion a temperature at least equal to 150° Wedgewood. It has not hitherto been chrystallized.

When heated in an open vessel, it combines with oxygen, and assumes a green colour; and if the heat is continued, acquires a tinge of purple. The oxide of nickel, according to Klaproth, is composed of 77 parts of nickel and 23 of oxygen.

Nickel has not been combined with carbon nor hydrogen, but it combines readily with sulphur and phosphorus. Cronstedt found that sulphuret of neckel may be easily formed by fusion. The sulphuret which he obtained was yellow and hard, with small sparkling facets; but the nickel which he employed was impure.

Phosphuret of nickel may be formed either by fusing nickel along with phosphoric glass, or by dropping phosphorus into it while red-hot. It is of a white colour, and when broke, it exhibits the appearance of very slender prisms collected together. When heated the phosphorus burns, and the metal is oxidated. It is composed of 83 parts of nickel and 17 of phosphorus. The nickel however on which this experiment was made, was not pure.

Nickel is not acted upon by azote, nor does it combine with muriatic acid.

The alloys of this metal are but very imperfectly known. With gold it forms a white and brittle alloy; with copper a white, hard, brittle alloy, easily oxidized when exposed to the air; with iron it combines very readily, and forms an alloy whose properties have not been sufficiently examined; with tin it forms a white, hard, brittle mass, which swells up when heated; with lead it does not combine without difficulty; with silver and mercury it refuses to unite; its combination with platinum has not been tried.

The affinities of nickel, and its oxides, are, according to Bergman, as follows:

NICKEL	OXIDE OF NICKEL.
Iron,	Oxalic acid,
Cobalt,	Muriatic,
Arsenic,	Sulphuric,
Copper,	Tartaric,
Gold,	Nitric,
Tin,	Phosphoric,
Antimony,	Fluoric,
Platinum,	Saclactic,

Bismuth,	Succinic.
Lead,	Citric,
Silver,	Lactic,
Zinc,	Acetic,
Sulphur,	Arsenic,
Phosphorus.	Boracic,
	Prussic,
	Carbonic.

NICKEL, *ores of.* Hitherto nickel has been found in too small quantities to be applied to any use; of course there are no mines of nickel. It usually occurs in secondary mountains, and commonly accompanies cobalt. It has been found in different parts of Germany, in Sweden, Siberia, Spain, France, and Britain.

NICOLAITANS, in church history, christian heretics who assumed this name from Nicolas of Antioch; who, being a gentile by birth, first embraced judaism, and then christianity; when his zeal and devotion recommended him to the church of Jerusalem, by whom he was chosen one of the first deacons.

NICOTIANA, *tobacco*, a genus of the monogynia order. in the pentandria class of plants, and in the natural method ranking under the 28th order, luridæ. The corolla is funnel-shaped, with a plaited limb; the stamina inclined; the capsule bivalved and bilocular. There are seven species, of which the most remarkable is the tabacum (see Plate C. Nat. Hist. fig. 297), or common tobacco-plant. This was first discovered in America by the Spaniards about the year 1560, and by them imported into Europe. It had been used by the inhabitants of America long before; and was called by those of the islands yoli, and pætun by the inhabitants of the continent. It was sent into Spain from Tabaco, a province of Yucatan, where it was first discovered, and whence it takes its common name.

There are two varieties of that species of nicotiana which is cultivated for common use; and which are distinguished by the names of Oronokoe, and sweet-scented tobacco. They differ from each other in the figure of their leaves; those of the former being longer and narrower than the latter. They are tall herbaceous plants, growing erect with fine foliage, and rising with a strong stem from six to nine feet high. The stalk, near the root, is upward of an inch diameter, and surrounded with a kind of hairy or velvet clammy substance, of a yellowish-green colour. The leaves are rather of a deeper green, and grow alternately at the distance of two or three inches from each other. They are oblong, of a spear-shaped oval, and simple; the largest about twenty inches long. but decreasing in size as they ascend, till they come to be only ten inches long, and about half as broad. The face of the leaves is much corrugated, like those of spinach when full-ripe. Before they come to maturity, when they are about five or six inches long, the leaves are generally of a full green, and rather smooth; but as they increase in size, they become rough, and acquire a yellowish cast. The stem and branches are terminated by large bunches of flowers collected into clusters, of a delicate red; the edges, when full-blown, inclining to a pale purple. They continue in succession till the end of the summer; when they are succeeded by seeds of a brown colour, and kidney-shaped. These are very small, each capsule containing about 1000; and the whole produce of a single plant is reckoned at about 350,000. The seeds ripen in the month of September.

Mr. Carver informs us, that the Oronokoe, or, as it is called, the long Virginian tobacco, is the kind best suited for bearing the rigour of a northern climate; the strength, as well as the scent, of the leaves, being greater than that of the other. The sweet-scented sort flourishes most in a sandy soil, and in a warm climate, where it greatly exceeds the former in the celerity of its growth; and is likewise, as its name intimates, much more mild and pleasant.

Culture.—Tobacco thrives best in a warm, kindly. rich soil, that is not subject to be overrun by weeds. In Virginia, the soil in which it thrives best is warm, light, and inclining to be sandy; and therefore if the plant is to be cultivated in Britain, it ought to be planted in a soil as nearly of the same kind as possible. Other kinds of soil might probably be brought to suit it, by a mixture of proper manure; but we must remember, that whatever manure is made use of must be thoroughly incorporated with the soil. The best situation for a tobacco-plantation is the southern declivity of a hill rather gradual than abrupt, or a spot that is sheltered from the north winds: but at the same time it is necessary that the plants enjoy a free air; for without that they will not prosper.

Having sown the seed, on the least apprehension of a frost after the plants appear, it will be necessary to spread mats over the beds, a little elevated from the ground by poles laid across, that they may not be crushed. When the tobacco has risen to the height of more than two feet, it commonly begins to put forth the branches on which the flowers and seeds are produced; but as this expansion, if suffered to take place, would drain the nutriment from the leaves, which are the most valuable part, and thereby lessen their size and efficacy, it becomes needful at this stage to nip off the extremity of the stalk to prevent its growing higher. In some climates the top is commonly cut off when the plant has 15 leaves: but if the tobacco is intended to be a little stronger than usual, this is done when it has only 13.

The apparent signs of maturity are these: the leaves, as they approach a state of ripeness, become more corrugated or rough; and when fully ripe appear mottled, with yellowish spots on the raised parts; whilst the cavities retain their usual green colour.

Tobacco is subject to be destroyed by a worm; and without proper care to exterminate this enemy, a whole field of plants may soon be lost. This animal is of the horned species, and appears to be peculiar to the tobacco-plant; so that in many parts of America it is distinguished by the name of the tobacco-worm. In what manner it is first produced, or how propagated, is unknown: but it is not discernible till the plants have attained about half their height; and then appears to be nearly as large as a gnat. Soon after this it lengthens into a worm; and by degrees increases in magnitude to the bigness of a man's finger. In shape it is regular from its head to its tail, without any diminution at either extremity. The colour of its skin is, in general, green, interspersed with several spots of yellowish white; and the whole covered with a short hair scarcely to be discerned. These worms are found the most predominant during the end of July and the beginning of August; at which

time the plants must be particularly attended to, and every leaf carefully searched. As soon as a wound is discovered (and it will not be long before it is perceptible), care must be taken to destroy the cause of it, which will be found near it, and from its unsubstantial texture may easily be crushed.

When the tobacco is fit for being gathered, on the first morning that promises a fair day, before the sun is risen, take an axe or a long knife, and holding the stalk near the top with one hand, sever it from its root with the other, as low as possible. Lay it gently on the ground, taking care not to break off the leaves, and there let it remain exposed to the rays of the sun throughout the day, or until the leaves, according to the American expression, are entirely wilted; that is, till they become limber, and will bend any way without breaking. But if the weather should prove rainy without any intervals of sunshine, and the plants appear to be fully ripe, they must be housed immediately. This must be done, however, with great care that the leaves, which are in this state very brittle, may not be broken. They are next to be placed under proper shelter, either in a barn or covered hovel, where they cannot be affected by rain or too much air, thin scattered on the floor; and if the sun does not appear for several days, they must be left to wilt in that manner; but in this case the quality of the tobacco will not be quite so good.

When the leaves have acquired the above-mentioned flexibility, the plants must be laid in heaps, or rather in one heap if the quantity is not too great, and in about 24 hours they will be found to sweat. But during this time, when they have lain for a little while, and begin to ferment, it will be necessary to turn them; bringing those which are in the middle to the surface, and placing those which are at the surface in the middle. The longer they lie in this situation, the darker coloured is the tobacco. After they have lain for three or four days, for a longer continuance might make the plants turn mouldy, they may be fastened together in pairs with cords or wooden pegs, near the botton of the stalk, and hung across a pole, with the leaves suspended in the same covered place, a proper interval being left between each pair. In about a mounth the leaves will be thoroughly dried, and of a proper temperature to be taken down. This state may be ascertained by their appearing of the same colour with those imported from America. But this can be done only in wet weather. The tobacco is exceedingly apt to attract the humidity of the atmosphere, which gives it a pliability that is absolutely necessary for its preservation; for if the plants are removed in a very dry season, the external parts of the leaves will crumble into dust, and a considerable waste will ensue.

Cure.—As soon as the plants are taken down, they must again be laid in a heap, and pressed with heavy logs of wood for about a week; but this climate may possibly require a longer time. While they remain in this state it will be necessary to introduce your hand frequently into the heap, to discover whether the heat is not too intense; for in large quantities this will sometimes be the case, and considerable damage will be occasioned by it. When they are found to heat too much, that is, when the heat exceeds a moderate glowing warmth, part of the weight by which they are pressed must be taken away; and the cause being removed, the effect will cease. This is called the second or last sweating; and, when completed, which it generally will be about the time just mentioned, the leaves may be stripped from the stalks for use. Many, however, omit this last sweating.

When the leaves are stripped from the stalks, they are to be tied up in bunches or hands, and kept in a cellar or other damp place; though if not handled in dry weather, but only during a rainy season, it is of but little consequence in what part of the house or barn they are laid up. At this period the tobacco is thoroughly cured, and as proper for manufacturing as that imported from the colonies.

Tobacco is made up into rolls by the inhabitants of the interior parts of America, by means of a machine called a tobacco-wheel. With this machine they spin the leaves after they are cured, into a twist of any size they think fit; and having folded it into rolls of about 20 pounds each, they lay it by for use. In this state it will keep for several years, and be continually improving, as it always grows milder. The Illinois usually form it into carrots; which is done by laying a number of leaves, when cured, on each other after the ribs have been taken out, and rolling them round with packthread till they become cemented together. These rolls commonly measure about 18 or 30 inches in length, and nine round in the middle part.

NICTITATING Membrane. See Comparative Anatomy.

NIGELLA, *fennel flower*, or *devil in a bush*, a genus of the pentagynia order, belonging to the pentandria class of plants. There is no calyx; the petals are five, and five trifid nectaria within the corolla; there are five connected capsules. There are five species, all of them annuals, and natives of the warm parts of Europe; and rising from a foot to a foot and a half high, adorned with blue or white flowers. They are propagated by seeds, which in a dry and warm situation will thrive very well; and the plants ripen seeds in this country.

NIGHT-MARE. See Medicine.

NIGRINA, in botany, a genus of the monogynia order, belonging to the pentandria class of plants. The corolla is funnel-shaped; the calyx inflated; the stigma obtuse; the capsule bilocular.

NIGRINE. This ore has hitherto been found only near Passau in Bavaria, and at Arendaal in Norway, and near St. Gothard. It was discovered by professor Hunger. It is sometimes disseminated, but more commonly crystallized, in four-sided prisms, not longer than one-fourth of an inch. Primitive form a rhomboidal prism.

Colour reddish, yellowish, or blackish-brown; sometimes whitish-grey. Powder whitish-grey. Lustre waxy, or nearly metallic. Texture foliated. Brittle. Specific gravity 3.510. Muriatic acid, by repeated digestion, dissolves one-third of it. Ammonia precipitates from this solution a clammy yellowish substance. Infusible by the blow-pipe, and also in a clay crucible; but in charcoal is converted into a black opaque, porous slag.

According to the analysis of Klaproth it is composed of

33 oxide of titanium
35 silica
33 lime
———
101

The mineral called sphene by Hauy belongs to this species. According to the analysis of Cordier it is composed of

33.3 oxide of titanium
28.0 silica
32.2 lime.
———
93.5

NIHIL DICIT, a failure in the defendant to put in an answer to the plaintiff's declaration, &c. by the day assigned for that purpose, by which omission judgment of course is had against him.

NIMBUS, in atiquity, a circle observed on certain medals, or round the head of some emperors, answering to the circles of light drawn around the images of saints. The nimbus is seen on the medals of Maurice, Phocas, and others, even of the upper empire. See also METEOROLOGY.

NIPA, a genus of the natural order of palms. The male has a spathe; the corolla is six-petalled. The female has a spathe; corolla none; drupes angular.

There is one species, a native of the E. Indies. The leaves are used in making mats.

NIPPERS, in a ship, are small ropes about a fathom or two long, with a little truck at one end, and sometimes only a wale-knot. Their use is to help holding off the cable from the main or jeer-capstan, where the cable is so slimy, so wet, and so great, that they cannot strain it, to hold it off with their bare hands.

NISI PRIUS, in law, a commission directed to the judges of assize; empowering them to try all questions of fact issuing out of the courts at Westminster that are then ready for trial by jury. The original of which name is this: all causes commenced in the courts of Westminster-hall are, by course of the courts, appointed to be tried on a day fixed in some Easter or Michaelmas term, by a jury returned from the county wherein the cause of action arises; but with this proviso, nisi prius justiciarii ad assisas capiendas venerint: that is, unless before the day prefixed the judges of assize come into the county in question, which they always do in the vacation preceding each Easter and Michaelmas term, and there try the cause. And then, upon the return of the verdict given by the jury to the court above, the judges there give judgment for the party to whom the verdict is found. 3. Black. 59. See ASSIZES.

NISSOLIA, a genus of the decandria order, in the diadelphia class of plants, and in the natural method ranking under the 32d order, papilionaceæ. The calyx is quinquedentate: the capsule monospermous, and terminated by a ligulated wing. There are two species, trees of Carthagena.

NITIDULA, a genus of insects of the coleoptera order. The generic character is, antennæ clavate, the club solid; shells margined; head prominent; thorax a little flattened, margined. There are upwards of 30 species of this genus.

NITRARIA, a genus of the monogynia order, in the dodecandria class of plants, and in the natural method ranking with those of which the order is doubtful. The corolla is pentapetalous, with the petals arched at the top; the calyx quinquefid; the stamina 15; the fruit a monospermous plum. There is one species, a shrub of Siberia.

NITRATS, salts formed by the nitric acid. The most important of the nitrats have been long known; and in consequence of the singular properties which they possess, no class of bodies has excited greater attention, or been examined with more unwearied industry. See NITRE. They may be distinguished by the following properties:

1. Soluble in water, and capable of crystallizing by cooling. 2. When heated to redness, along with combustible bodies, a violent combustion and detonation are produced. 3. Sulphuric acid disengages from them fumes, which have the odour of nitric acid. 4. When heated along with muriatic acid, oxymuriatic acid is exhaled. 5. Decomposed by heat, and yield at first oxygen gas. The nitrats at present known are 12 in number. Few of them combine with an excess of acid or of base, so that there are hardly any supernitrats, or subnitrats.

NITRE, or *nitrat of potass*. As this salt, known also by the name of saltpetre, is produced naturally in considerable quantities, particularly in Egypt, it is highly probable that the ancients were acquainted with it; but scarcely any thing certain can be collected from their writings. If Pliny mentions it at all, he confounds it with soda, which was known by the names of nitron and nitrum. It is certain, however, that it has been known in the East from time immemorial. Roger Bacon mentions this salt in the 13th century under the name of nitre.

No phenomenon has excited the attention of chemical philosophers more than the continual reproduction of nitre in certain places after it had been extracted from them. Prodigious quantities of this salt are necessary for the purposes of war; and as nature has not laid up great magazines of it, as she has of some other salts, this annual reproduction is the only source from which it can be procured. It became therefore of the utmost consequence, if possible, to discover the means which nature employed in forming it, in order to enable us to imitate her processes by art, or at least to accelerate and facilitate them at pleasure. Numerous attempts accordingly have been made to explain and to imitate these processes.

Lemery the younger advanced, that all the nitre obtained exists previously in animals and vegetables; and that it is formed in these substances by the processes of vegetation and animalization. But it was soon discovered that nitre exists, and is actually formed, in many places where no animal nor vegetable substance had been decomposed; and consequently this theory was as untenable as the former. So far indeed is it from being true that nitre is formed by these processes alone, that the quantity of nitre in plants has been found to depend entirely on the soil in which they grow.

At last, by the numerous experements of several French philosophers, particularly by those of Thouvenel, it was discovered that nothing else is necessary for the production of nitre than a basis of lime, heat, and an open but not too free communication with dry atmospheric air. When these circumstances combine the acid

is first formed, and afterwards the alkali makes its appearance. How the air furnishes meterials for this production is easily explained, now that the component parts of the nitric acid are known to be oxygen and azote: but how lime contributes to their union it is not so easy to see. The appearance of the potass is equally extraordinary. If any thing can give countenance to the hypothesis that potass is composed of lime and azote, it is this singular fact.

Nitre is found abundantly on the surface of the earth in India, South America, and even in some parts of Spain. In Germany and France it is obtained by means of artificial nitre-beds. These consist of the refuse of animal and vegetable bodies undergoing puterfaction, mixed with calcareous and other earths. It has been ascertained that if oxygen gas is presented to azote at the instant of its disengagement, nitric acid is formed. This seems to explain the origin of the acid in these beds. The azote disengaged from these putrefying animal substances combines with the oxygen of the air. The potass is probably furnished, partly at least, by the vegetables and the soil.

The nitre is extracted from these beds by lixiviating the earthy matters with water. This water, when sufficiently impregnated, is evaporated, and a brown-coloured salt obtained, known by the name of crude nitre. It consists of nitre, common salt, nitrat of lime, and various other salts. The foreign salts are either separated by repeated chrystallizations, or by washing the salts repeatedly with small quantities of water; for the foreign salts being more soluble are taken up first.

Nitre, when slowly evaporated, is obtained in six-sided prisms, terminated by six-sided pyramids; but for most purposes it is preferred in an irregular mass, because in that state it contains less water. The primitive form of its crystals, according to Hauy, is a rectangular octahedron, composed of two four-sided pyramids applied base to base; two of the sides are inclined to the other pyramid at an angle of 120°; the other two at an angle of 111°. The form of its integrant particles is the tetrahedron. The six-sided prisms is the most common form which it assumes. Sometimes, instead of six-sided pyramids, these prisms are terminated by 18 facets, disposed in three ranges of six, as if three truncated pyramids were piled on each other; sometimes it crystallizes in tables.

The specific gravity of nitre is 1.9369. Its taste is sharp, bitterish, and cooling. It is very brittle. It is soluble in seven times its weight of water at the temperature of 60°, and in nearly its own weight of boiling water. It is not altered by exposure to the air.

When the solution of nitre is exposed to a boiling heat, part of the salt is evaporated along with the water, as Wallerius, Kirwan, and Lovoisier, observed successively. When exposed to a strong heat it melts, and congeals by cooling into an opaque mass, which has been called mineral crystal. Whenever it melts it begins to disengage oxygen; and by keeping it in a red heat about the third of its weight of that gas may be obtained: towards the end of the process azotic gas is disengaged. If the heat is continued long enough the salt is completely decomposed, and pure potass remains behind.

It detonates more violently with combustible bodies than any of the other nitrats. When mixed with one-third part of its weight of charcoal, and thrown into a red-hot crucible, or when charcoal is thrown into red-hot nitre, detonation takes place, and one of the most brilliant combustions that can be exhibited. The residuum is carbonat of potass. It was formerly called nitre fixed by charcoal. A still more violent detonation is produced by using phosphorus instead of charcoal. When a mixture of nitre and phosphorus is struck smartly with a hot hammer a very violent detonation is produced.

Nitre oxidizes all the metals at a red heat, even gold and platinum.

Nitre, according to Bergman, is composed of

31	acid
61	potass
8	water.
100	

According to the last experiments of Kirwan, after being dried in the temperature of 70°, it is composed of

44.0	acid
51.8	potass
4.2	water.
100.0	

Nitre is decomposed by the following salts:

1. Sulphats of soda, ammonia, magnesia, alumina.
2. Muriat and acetat of barytes.

One of the most important compounds formed by means of nitre is gunpowder, which has completely changed the modern art of war. See Gunpowder.

NITRIC ACID seems to have been first obtained in a separate state by Raymond Lully, who was born at Majorca in 1235. He procured it by distilling a mixture of nitre and clay. It was afterwards denominated aquafortis, and spirit of nitre. The name nitric acid was first given it in 1787 by the French chemists; it was immediately before called nitrous acid.

1. It is generally obtained in large manufactories by distilling a mixture of nitre and clay; but the acid procured by this process is weak and impure. Chemists generally prepare it by distilling three parts of nitre and one of sulphuric acid in a glass retort. The neck of the retort must be luted into a receiver, from which there passes a glass tube into a bottle with two mouths, containing a little water, and furnished with a tube of safety; which is a tube open at its upper end, and having its lower end plunged in water. The water prevents any communication between the external air and the inside of the apparatus. If a vacuum happens to be formed within the vessels, the external air reaches down through the tube, and prevents any injury to the vessels. On the other hand, if air is generated in the vessels it forces the water up the tube, the height of which becomes thus the measure of the elasticity of the air in the vessels. By this contrivance the apparatus is in no danger of being broken, which otherwise might happen. From the other mouth of this bottle there passes a tube into a pneumatic apparatus, to collect the gas which is evolved during the process. The retort is to be heated gradually almost to redness. The nitric acid comes over, and is condensed in the receiver; while the common air of the vessels, and a quantity of oxygen gas which is evolved, especial-

ly towards the end of the process, passes into the pneumatic apparatus, and the water in the bottles is impregnated with some acid which is not condensed in the receiver.

The acid thus obtained is of a yellow colour, and almost always contains muriatic and sometimes sulphurous acid. These may be removed by distilling it over again with a moderate heat, and changing the receiver after the first portion, which contains all the foreign acids, has passed. It still contains a quantity of nitrous gas, to which it owes its colour and the red fumes which it exhales. This gas may also be expelled by the application of heat. Pure nitric acid remains behind, transparent and colourless, like water.

When newly prepared in this manner it is a liquid as transparent and colourless as water; but the affinity between its component parts is so weak, that the action of light is sufficient to drive off a part of its oxygen in the form of gas; and thus, by converting it partly into nitrous gas, to make it assume a yellow colour. Its taste is exceedingly acid and peculiar. It is very corrosive, and tinges the skin of a yellow colour, which does not disappear till the epidermis comes off. It is constantly emitting white fumes which have an acrid disagreeable odour.

It has a strong affinity for water, and has never yet been obtained except mixed with that liquid. When concentrated it attracts moisture from the atmosphere, but not so powerfully as sulphuric acid. It also produces heat when mixed with water, owing evidently to the concentration of the water.

The specific gravity of the strongest nitric acid that can be procured is 1.583; but at the temperature of 60°, Mr. Kirwan could not procure it stronger than 1.5543.

As this liquid acid is a compound of two ingredients, namely, pure nitric acid and water, it becomes an object of the greatest consequence to ascertain the proportion of each of these parts. This problem has lately occupied the attention of Mr. Kirwan, who has endeavoured to solve it in the following manner:

He dried a quantity of crystallized carbonat of soda in a red heat, and dissolved it in water, in such a proportion that 367 grains of the solution contained 50.05 of alkali. He saturated 367 grains of this solution with 147 grains of nitric acid, the specific gravity of which was 1.2754; and which he ascertained to contain 45.7 per cent. of acid, of the specific gravity 1.5543, chosen by him as a standard. The carbonic acid driven off amounted to 14 grains. On adding 939 grains of water the specific gravity of the solution, at the temperature of 58.5°, was 1.0401. By comparing this with a solution of nitrat of soda, of the same density, he found that the salt contained in it amounted to $\frac{1}{16.901}$ of the whole. There was an excess of acid of about two grains. The weight of the whole was 1439 grains: the quantity of salt consequently was $\frac{1439}{16.901} = 85.142$ grains. The quantity of alkali was $50.05 - 14 = 36.05$. The quantity of standard acid employed was 66.7. The whole therefore amounted to 102.75 grains; but as only 85.142 grains entered into the composition of the salt, the remaining 17.608 must have been pure water mixed with the nitric acid. But if 66.7 of standard acid contain 17.608 of water, 100 parts of the same acid must contain 26.38. One hundred parts of standard nitric acid, therefore, are composed of 73.62 parts of pure nitric acid and 26.38 of water.

Mr. Davy considers as pure acid the permanently elastic vapour or gas formed by saturating nitrous gas with oxygen gas. This gas is of a pale-yellow colour, and a specific gravity 2.44 times that of air. It is not pure acid, containing undoubtedly a portion of nitrous gas. The following table exhibits the proportion of this acid contained in nitric acid of different densities, according to the experiments of that ingenious chemist:

100 Parts Nitric Acid, of Sp. Gr.	True Acid.	Water.
1.5040	91.55	8.45
1.4475	80.39	19.61
1.4285	71.65	28.35
1.3906	62.96	37.04
1.3551	56.88	43.12
1.3186	52.03	47.97
1.3042	49.04	50.96
1.2831	46.03	53.97
1.2090	45.27	54.73

When nitric acid is exposed to the action of heat it boils at the temperature of 248, and evaporates completely without alteration; but when made to pass through a red-hot porcelain tube it is decomposed, and converted into oxygen and azotic gas. When cooled down to —66 it begins to congeal; and when agitated it is converted into a mass of the consistence of butter.

Oxygen gas has no action whatever on nitric acid; but all the simple combustibles decompose it, unless we are to except the diamond. When poured upon sulphur or phosphorus at a high temperature it sets them on fire; but at a moderate temperature it converts them slowly into acids, while nitrous gas is exhaled. It inflames charcoal also at a high temperature; and even at the common temperature, provided the charcoal is perfectly dry and minutely divided. Hydrogen gas produces no change on it at the temperature of the atmosphere; but when passed along with it through a red-hot porcelain tube it detonates with great violence; water is formed, and azotic gas evolved.

When this acid is poured upon oils it sets them on fire. This is occasioned by a decomposition both of the acid and oil. The oxygen of the acid combines with the carbon and with the hydrogen of the oils, and at the same time lets go a quantity of caloric. Hence we see that the oxygen which enters into the composition of the nitric acid still contains a great deal of caloric; a fact which is confirmed by a great number of other phenomena. The combustion of oils by this acid was first taken notice of by Borrichius and Slare; but it is probable that Homberg communicated it to Slare. In order to set fire to the fixed oils it must be mixed with some sulphuric acid; the reason of which seems to be, that these oils contain water, which must be previously removed. The sulphuric acid combines with this water, and allows the nitric acid, or rather the oil and nitric acid together, to act. The drying oils do not require any sulphuric acid:

they have been boiled, and consequently deprived of all moisture.

Azote has no action on nitric acid; but muriatic acid decomposes it by combining with a portion of its oxygen nitrous gas and oxymuriatic gas being evolved.

It is capable of oxidizing all the metals, except gold, platinum, and titanium. It appears from the experiments of Scheffer, Bergman, Sage, and Tillet, that nitric acid is capable of dissolving (and consequently of oxidizing) a very minute quantity even of gold.

It even sets fire to zinc, bismuth, and tin, if it is poured on them in fusion, and to filings of iron if they are perfectly dry.

Nitric acid combines with alkalies, earths, and the oxides of metals, and forms compounds, which are called nitrats.

The order of its affinities is as follows:

Barytes,
Potass,
Soda,
Strontian,
Lime,
Magnesia,
Ammonia,
Glucina,
Alumina,
Zirconia.

Nitric acid is one of the most important instruments of analysis which the chemist possesses: nor is it of inferior consequence when considered in a political or commercial view, as it forms one of the most essential ingredients of gunpowder. Its nature and composition accordingly have long occupied the attention of philosophers; and from their experiments it appears, that nitric acid is composed of azote and oxygen; consequently nitrous gas is also composed of the same ingredients. And as nitrous gas absorbs oxygen, even from common air, and forms with it nitric acid, it is evident that nitric acid contains more oxygen than nitrous gas. But it is exceedingly difficult to ascertain the exact proportions of the component parts of this acid. Lavoisier concluded, from his experiments on the decomposition of nitre by charcoal, that nitric acid is composed of one part of azote and four parts of oxygen. But Davy has shown that this decomposition is more complicated than had been supposed; and that Lavoisier's experiments by no means warrant the conclusion which he drew from them. Cavendish, on the other hand, concluded, from his experiments, that the acid which he formed, by combining together azote and oxygen by means of electricity, is composed of one part of azote and 2.346 of oxygen. With this result the late experiments of Mr. Davy corresponded very nearly. He formed his standard acid by combining together known quantities of nitrous gas and oxygen. According to him 100 parts of pure nitric acid are composed of

29.5 azote
70.5 oxygen
——
100.0;

or one part of azote, and 2.39 of oxygen.

Nitric acid is seldom in a state of absolute purity, holding usually a certain portion of nitrous gas in solution. In this state it is distinguished by the name of nitrous acid; a compound of considerable importance. See Nitrous Acid.

NITRITES, are salts formed from nitrats, saturated with nitrous gas. See Nitrats.

The existence of these salts was first pointed out by Bergman and Scheele; the two philosophers to whom we are indebted for the first precise notions concerning the difference between nitric and nitrous acids. They cannot be formed by combining directly nitrous acid with the different earthy and alkaline bases; nor have any experiments made to combine nitrous gas with the nitrats been attended with success.

The only method of obtaining these salts at present known, is that which was long ago pointed out by Bergman and Scheele. It consists in exposing a nitrat to a pretty strong heat till a quantity of oxygen gas is disengaged from it. What remains in the retort after this process is a nitrite; but the length of time necessary for producing this change has not yet been ascertained with any degree of precision. If the heat is applied too long the nitrat will be totally decomposed, and nothing but the base will remain, as happened to some of the French chemists on attempting to repeat the process of Bergman and Scheele.

Nitrite of potass is the only salt formed by this process, of which an account has been given. Scheele's process for obtaining it is as follows: Fill a small retort with nitre, and keep it red-hot for half an hour. When it is allowed to cool it is found in the state of a nitrite. It deliquesces when exposed to the air: and red vapours of nitrous acid are exhaled when any other acid is poured upon it.

As the nitrites have never been examined by chemists, and as it has not even been determined whether any considerable number of the nitrats can be converted into these salts, it would be in vain, in the present state of our knowledge, to attempt a particular description of them. It may, however, be considered as exceedingly probable that no such salts as the nitrites of ammonia, glucina, yttria, alumina, and zirconia, exist or can be formed, at least by the process of Scheele and Bergman; for the nitrats with these bases are decomposed completely by the action of a heat too moderate to hope for the previous emission of oxygen gas.

From the few observations that have been made, it may be concluded that the nitrites are in general deliquescent, very soluble in water, decomposible by heat as well as nitrates; that their taste is cooling like that of the nitrats, but more acrid and nitrous: that by exposure to the air they are gradually converted into nitrats by absorbing oxygen; but this change takes place exceedingly slowly.

NITRO-MURIATIC acid. When muriatic acid is mixed with nitric acid, the mixture is nitro-muriatic acid, which was formerly known by the name of aqua-regia.

NITROUS ACID. The liquid at present called nitrous acid by chemists, may be formed by causing nitrous gas to pass through nitric acid. The gas is absorbed, and the acid assumes a yellow colour; and its specific gravity is diminished. It is then denominated nitrous acid. It is always in this state that it is obtained by dis-

tilling a mixture of sulphuric acid and nitre. The acid of commerce is always nitrous acid. The nitric and nitrous acids were first distinguished with accuracy by Scheele.

The nature of nitrous acid was first investigated by Dr. Priestley, who demonstrated, by very decisive experiments, that it is a compound of nitric acid and nitrous gas. This opinion was embraced, or rather it was first fully developed, by Morveau. But the theory of Lavoisier, which supposed the difference between nitric and nitrous acids to depend merely on the first containing a greater proportion of oxygen than the second, for some time drew the attention of chemists from the real nature of nitrous acid. Raymond published a dissertation in 1796, to demonstrate the truth of the theory of Priestley and Morveau; and the same thing has been done still more lately by Messrs. Thomson and Davy. At present it is allowed by every one, that nitrous acid is merely nitric acid more or less impregnated with nitrous gas.

This being the case, and nitric acid being capable of absorbing very different proportions of nitrous gas, it is evident that there must be a great variety of nitrous acids, differing from each other in the proportion of nitrous gas which they contain; unless we choose to confine the term nitrous acid to the compound formed by saturating nitric acid completely with nitrous gas.

When nitrous gas is placed in contact with nitric acid, the acid absorbs it slowly, and acquires first a pale-yellow colour, then a bright yellow. When a considerable portion more of nitrous gas is absorbed, the acid becomes dark orange, then olive, which increases in intensity with the gas absorbed; then it becomes of a bright green; and, lastly, when fully saturated, it becomes blue-green. Its volume and its volatility also increase with the quantity of gas absorbed; and when fully saturated it assumes the form of a dense vapour, of an exceedingly suffocating odour, and difficultly condensible by water. In this state of saturation it is distinguished by Dr. Priestley by the name of nitrous acid vapour. It is of a dark-red colour, and passes through water partly without being absorbed. The quantity of nitrous gas absorbed by nitric acid is very great. Dr. Priestley found, that a quantity of acid, equal in bulk to four pennyweights of water, absorbed 130 ounce-measures of gas without being saturated. The component parts of nitrous acid, of different colours and densities, may be seen in the following table, drawn up by Mr. Davy, from experiments made by him on purpose, with much precision:

100 Parts.	Sp. Grav.	Component Parts. Nitric Acid.	Water.	Nitrous Gas.
Solid nitric acid	1.504	91.55	8.45	—
Yellow nitrous	1.502	90.5	8.3	2
Bright yellow	1.500	88.94	8.10	2.96
Dark orange	1.480	86.84	7.6	5.56
Light olive	1.479	86.00	7.55	6.45
Dark olive	1.478	85.4	7.5	7.1
Bright green	1.476	84.8	7.44	7.76
Blue green	1.475	84.6	7.4	8.00

The colour of nitrous acid depends, in some measure, also on the proportion of water which it contains. When to yellow nitrous acid concentrated, a fourth part by weight of water is added, the colour is changed to a fine green; and when equal parts of water are added, it becomes blue. Dr. Priestley observed, that water impregnated with this acid in the state of vapour, became first blue, then green, and lastly yellow. A green nitrous acid became orange-coloured while hot, and retained a yellow tinge when cold. A blue acid became yellow on being heated in a tube hermetically sealed. An orange-coloured acid, by long keeping, became green, and afterwards of a deep blue; and when exposed to air resumed its original colour. When nitrous acid is exposed to heat the nitrous gas is expelled, and nitric acid remains behind. The gas, however, carries along with it a quantity of acid, especially if the acid is concentrated. But nitrous acid vapour is not altered in the least by exposure to heat.

It is not altered by oxygen gas, common air, nor by azotic gas.

The simple combustibles and metals act upon it precisely as on nitric acid. It answers much better than nitric acid for inflaming oils and other similar bodies.

It converts sulphurous and phosphorous acids into sulphuric and phosphoric.

Nitrous acid vapour is absorbed by sulphuric acid, but seemingly without producing any change; for when water is poured into the mixture, the heat produced expels it in the usual form of red fumes. The only singular circumstance attending this impregnation is, that it disposes the sulphuric acid to crystallize.

NOBILITY, a quality that ennobles, and raises a person possessed of it above the rank of a commoner.

The civil state of England consists of the nobility and commonalty. The nobility are all those who are above the degree of knight, under which term is included that of a baronet; namely, dukes, marquises, earls, viscounts, and barons. 1 Black. 396.

NOCTURNAL, NOCTURLABIUM, an instrument chiefly used at sea, to take the altitude or depression of some stars about the pole, in order to find the latitude, and hour of the night.

Some nocturnals are hemispheres, or planispheres, on the plane of the equinoctial. Those commonly in use among seamen are two; the one adapted to the polar star, and the first of the guards of the little bear; the other to the pole-star, and the pointers of the great bear.

This instrument consists of two circular plates (see Plate XCIV. Miscel. figure 173), applied to each other. The greater, which has a handle to hold the instrument, is about two inches and a half in diameter, and is divided into twelve parts, agreeing to the twelve months, and each month subdivided into every fifth day; and so that the middle of the handle corresponds to that day of the year wherein the star here regarded has the same right ascension with the sun. If the instrument is fitted for two stars, the handle is made moveable. The upper left circle is divided into twenty-four equal parts for the twenty-four hours of the day, and each hour subdivided into quarters. These twenty-four hours are noted by twenty-four teeth, to be told in the night. Those at the hours 12 are distinguished by their length. In the cen-

tre of the two circular plates is adjusted a long index, A, moveable upon the upper plate; and the three pieces, viz. the two circles and index, are joined by a rivet which is pierced through the centre with a hole, through which the star is to be observed.

To use the Nocturnal.—Turn the upper plate till the long tooth, marked 12, is against the day of the month on the under plate: then, bringing the instrument near the eye, suspend it by the handle with the plane nearly parallel to the equinoctial; and viewing the pole-star through the hole of the centre, turn the index about till, by the edge coming from the centre, you see the bright star, or guard, of the little bear (if the instrument is fitted to that star): then that tooth of the upper circle, under the edge of the index, is at the hour of the night on the edge of the hour-circle: which may be known without a light, by counting the teeth from the longest, which is for the hour 12.

NODE. See SURGERY.

NODES. See ASTRONOMY.

NOETIANS, in church history, christian heretics in the third century, followers of Noetius, a philosopher of Ephesus, who it is said pretended that he was another Moses, sent by God, and his brother was a new Aaron; his doctrine consisted in affirming that there was but one person in the Godhead, and that the Word and the Holy Spirit were but external denominations given to God in consequence of different operations; that as creator he is called Father; as incarnate, Son; and as descending on the apostles, Holy Ghost.

NOLANA, a genus of the monogynia order, in the pentandria class of plants, and in the natural method ranking under the 41st order, asperifoliæ. The corolla is campanulated; the style situated betwixt the germens; the seeds are bilocular, and resemble berries. There is one species, an annual of Peru.

NOLLE PROSEQUI, is used where the plaintiff proceeds no farther in his action, and may be as well before as after a verdict, and is stronger against a plaintiff than a nonsuit, which is only a default in appearance; but this is a voluntary acknowledgment that he has no cause of action. Impey's B. R.

NOMBRIL POINT, in heraldry, is the next below the fess-point, or the very centre of the escutcheon.

NOME, or NAME, in algebra, denotes any quantity with a sign prefixed or added to it, whereby it is connected with some other quantity, upon which the whole becomes a binomial, trinomial, or the like: thus $a + b$ is a binomial, $a + b + c$ is a trinomial, whose respective names or nomes are a and b for the first, and a, b, and c, for the second. See ALGEBRA.

NOMINATIVE, in grammar, the first case in nouns which are declinable.

NON-APPEARANCE, a default in not appearing in a court of judicature. Attorneys subscribing warrants for appearing in court are liable to attachment and fine for non-appearance. If a defendant does not appear and find bail upon a scire facias and rule given, judgment may be had against him.

NON COMPOS MENTIS, in law, is used to denote a person's not being of sound memory and understanding. Of these persons there are four different kinds, an ideot, a madman, a lunatic who has lucid intervals, and a drunkard who deprives himself of reason by his own act and deed. In all these cases except the last, one that is non compos mentis shall not loose his life for felony or murder: but the drunkard can have no indulgence on account of the loss of his reason, for, in the eye of the law, his drunkenness does not extenuate but aggravate his offence.

NON EST INVENTUS, is a sheriff's return to a writ, that the defendant is not to be found.

NON-NATURALS, in medicine, so called because by their abuse they become the causes of diseases. See MEDICINE. The old physicians have divided the non-naturals into 6 classes, viz. the air, meats and drinks, sleep and watching, motion and rest, the passions of the mind, the retentions, and excretions.

NON-PROS. If the plaintiff neglects to deliver a declaration for two terms after the defendant appears, or is guilty of other delays or defaults against the rules of law in any subsequent stage of the action, he is adjudged not to pursue his remedy as he ought; and thereupon a nonsuit or non prosequitur is entered, and he is then said to be non-pros'd. 3 Black. 395.

NON-RESIDENCE. See RESIDENCE.

NONAGESIMAL, or *nonagesimal degree*, called also the midheaven, is the highest point, or 90th degree, of the ecliptic, reckoned from its intersection with the horizon at any time; and its altitude is equal to the angle that the ecliptic makes with the horizon at their intersection, or equal to the distance of the zenith from the pole of the ecliptic. It is much used in the calculation of solar eclipses.

NONAGON, a figure having nine sides and angles. In a regular nonagon, or that whose angles and sides are all equal, if each side is 1, its area will be 6.1818242 + $\frac{9}{4}$ of 70°, to the radius 1.

NONIUS. See VERNIER.

NONSUIT, in law, is where a person has commenced an action, and at the trial fails in his evidence to support it, or has brought a wrong action. There is this advantage attending a nonsuit, that the plaintiff, though he pays costs, may afterwards bring another action for the same cause, which he cannot do after a verdict against him. Tidd's K. B. Practice.

NONES, *nonæ*, in the Roman calender, the fifth day of the months January, February, April, June, August, September, November, and December; and the seventh of March, July, and October. March, May, July, and October, had six days in their nones; because these alone, in the ancient constitution of the year by Numa, had 31 days apiece, the rest having only 29, and February 30: but when Cæsar reformed the year, and made other months containing 31 days, he did not allot them six days of nones.

NORROY, the title of the third of the three kings at arms. See HERALDRY.

NORMAL, a perpendicular forming with another line a right angle.

NORWAY RAT. See MUS.

NOSE. See ANATOMY.

NOTARIAL ACTS, are those acts, in the civil law, which require to be done under the seal of a notary, and which are admitted as evidence in foreign courts.

NOTARY, is a person duly appointed to attest deeds and writings; he also protests and notes foreign and in-

land bills of exchange and promissory notes, translates languages and attests the same, enters and extends ship's protests, &c.

NOTATION, in arithmetic and algebra, the method of expressing numbers or quantities by signs or characters appropriated for that purpose. See ALGEBRA, ARITHMETIC, CHARACTER, &c.

NOTATION, in music, the manner of expressing, or representing by characters, all the different sounds used in music. The ancient notation was very different from that of the moderns. The Greeks employed for this purpose the letters of their alphabet, sometimes placing them erect, and sometimes inverting, mutilating, and compounding them in various manners, so as to represent by them all the different tones or chords used in their system. By a treatise of Alypius, professedly written to explain the Greek characters, we find that they amounted to no less a number than 1240. These were, however, rejected afterwards by the Latins, who introduced letters from their own alphabet, A, B, C, D, E, F, G, H, I, K, L, M, N, O, P, fifteen in number, and by which they expressed the sounds contained in the bisdiapason. For the great improvement upon this notation, which at length took place, and which is in part adopted at the present day, we are indebted to St. Gregory, the first pope of that name; who reflecting that in the bisdiapason, the sounds after Lichanos Meson, or the middle tone, were but a repetition of those which preceeded, and that every septenary in progression was precisely the same, reduced the number of letters to seven, viz. A, B, C, D, E, F, G: but to distinguish the second septenary from the first, the second was denoted by the small, and not the capital, Roman letters; and when it became necessary to extend the system farther, the small letters were doubled thus, aa, bb, cc, dd, ee, ff, gg. The stave, consisting of a variable number of parallel lines, the application of which some attribute to Guido, was afterwards introduced; and this was again meant to be improved upon by the adoption of small points, commas, accents, and certain little oblique strokes, occasionally interspersed in the stave, while also two colours, yellow and red, were used, a yellow line signifying the letter or note C, and a red line denoting that of F. Two methods of notation were long after employed for the viol and other stringed instruments, which were distinguished by the terms lyra-way and gamut-way; with this exception, that the literal notation for the lute is constantly called the tablature; concerning which, as also the notation by letters in general, it may be observed that they are a very inartificial practice, as was also the old method of notation for the flute and flagcolet by dots.

NOTE is a minute, or short writing, containing some article of business; in which sense we say, promissory note, note of hand, bank note. See BILLS of EXCHANGE.

NOTES, in music, charasters which by their various forms and situations on the staves, indicate the duration as well as the gravity or acuteness of the several sounds of a composition.

NOTICE, in law, is the making something known that a man was or might be ignorant of before, and it produces divers effects; for by it the party that gives the same shall have some benefit, which otherwise he should not have had: and by this means the party to whom the notice is given is made subject to some action or charge, that otherwise he would not have been liable to, and his estate in danger of prejudice. Co. Lit. 309.

The plaintiff and defendant are both bound at their peril to take notice of the general rules of the practice of the court; but if there is a special particular rule of court made for the plaintiff, or for the defendant, he for whom the rule is made ought to give notice of this rule to the other; or else he is not bound generally to take notice of it, nor shall be in contempt of the court although he does not obey it. 2 L. P. R. 204.

NOTONECTA, a genus of insects of the order hemiptera. The generic character is, snout inflected; antennæ shorter than thorax; wings coriaceous on the upper part, and crossed over each other; hind feet edged with hairs, and formed for swimming. The principal species of this are,

1. The notonecta glauca, a very common aquatic insect, inhabiting stagnant waters; and generally measuring about three parts of an inch in length. Its colour is grey-brown, and the upper wings are marked along the edges by a row of minute black specks. This insect is usually seen swimming on its back, in which situation it bears a most striking resemblance to a boat in miniature, the hind legs acting like a pair of oars, and impelling the animal at intervals through the water. it preys on the smaller inhabitants of the water, and flies only by night.

2. Notonecta striata, is much smaller than the preceding, not measuring more than a quarter of an inch in length, and is of a yellowish-grey colour, with numerous transverse undulated black lines or streaks: it is found in stagnant waters.

3. Notonecta minutissima, is an extremely small species, with grey wings, marked by longitudinal dusky spots: like the two former it is an inhabitant of stagnant waters, but is far less frequently observed than the rest, on account of its very small size. There are 17 species.

NOTOXUS, a genus of insects of the coleoptera order. The generic character is, antennæ filiform; feelers four, hatchet-shaped, jaw one toothed; thorax a little narrowed behind. There are 13 species, found in Europe and Asia.

NOVATIANS, a christian sect which sprang up in the third century, so called from Novatian, a priest of Rome, or Novatus, an African bishop, who separated from the communion of pope Cornelius, whom Novatian charged with a criminal lenity towards those who had apostatised during the persecution of Decius. He denied the church's power of remitting mortal sins.

NOVEL, in the civil law, a term used for the constitutions of several emperors, as of Justin, Tiberius, Leo, and more particularly for those of Justinian. The constitutions of Justinian were called novels, either from their producing a great alteration in the face of the ancient law, or because they were made on new cases, and after the revisal of the ancient code, compiled by the order of that emperor. Thus the constitutions of the emperors Theodosius, Valentinian, Marcian, &c. were also called novels, on account of their being published after the Theodosian code.

NOUN, in grammar, a part of speech, which signifies things without any relation to time; as a man, a house, sweet, bitter, &c.

NUCLEUS, in general, denotes the kernel of a nut, or even any seed inclosed within a husk. The term nucleus is also used for the body of a comet, otherwise called its head.

NUDE CONTRACT, a bare promise, without any consideration, and therefore void.

NUISANCE, signifies generally any thing that works hurt, inconvenience, or damage, to the property or person of another. Nuisances are of two kinds, public or private nuisance, and either affect the public or the individual. The remedy for a nuisance is by action on the case for damages. Every continuance of a nuisance is a fresh nuisance, and a fresh action will lie.

NUMBER, *kinds and distinctions of.* Mathematicians, considering number under a great many relations, have established the following distinctions. Broken numbers are the same with fractions. Cardinal numbers are those which express the quantity of units, as 1, 2, 3, &c. whereas ordinal numbers are those which express order, as 1st, 2d, 3d, &c. Compound number, one divisible by some other number besides unity; as 12, which is divisible by 2, 3, 4, and 6. Numbers, as 12 and 15, which have some common measure besides unity, and are said to be compound numbers among themselves.

Cubic number is the product of a square number by its root: such as 27, as being the product of the square number 9, by its root 3. All cubic numbers whose root is less than 6, being divided by 6, the remainder is the root itself: thus 27 ÷ 6 leaves the remainder 3, its root; 216, the cube of 6, being divided by 6, leaves no remainder; 343, the cube of 7, leaves a remainder 1, which added to 6, is the cube root; and 512, the cube of 8, divided by 6, leaves a remainder 2, which added to 6, is the cube root. Hence the remainders of the divisions of the cubes above 216, divided by 6, being added to 6, always give the root of the cube so divided, till that remainder is 5, and consequently 11 the cube root of the number divided. But the cube number above this being divided by 6, there remains nothing, the cube-root being 12. Thus the remainders of the higher cubes are to be added to 12, and not to 6, till you come to 18, when the remainder of the division must be added to 18; and so on ad infinitum.

Determinate number, is that referred to some given unit, as a ternary or three: whereas an indeterminate one, is that referred to unity in general, and is called quantity.

Homogeneal numbers, are those referred to the same unit; as those referred to different units are termed heterogeneal.

Whole numbers, are otherwise called integers. See INTEGER.

Rational number, is one commensurable with unity; as a number incommensurable with unity, is termed irrational or a surd. See SURD.

In the same manner a rational whole number, is that whereof unity is an aliquot part; a rational broken number, that equal to some aliquot part of unity; and a rational mixed number, that consisting of a whole number and a broken one.

Even number, that which may be divided into two equal parts without any fraction, as 6, 12, &c. The sum, difference, and product, of any number of even numbers, is always an even number.

An evenly even number, is that which may be measured, or divided, without any remainder, by another even number, as 4 by 2.

An unevenly even number, when a number may be equally divided by an uneven number, 20 by 5.

Uneven number, that which exceeds an even number, at least by unity, or which cannot be divided into two equal parts, as 3, 5, &c.

The sum or difference of two uneven numbers makes an even number; but the factum of two uneven ones makes an uneven number.

If an even number is added to an uneven one, or if the one is subtracted from the other, in the former case the sum, in the latter the difference, is an uneven number; but the factum of an even and uneven number is even.

The sum of any even number of uneven numbers is an even number; and the sum of any uneven number of uneven numbers is an uneven number.

Primitive or prime numbers, are those only divisible by unity, as 5, 7, &c. And prime numbers among themselves, are those which have no common measure besides unity, as 12 and 19.

Perfect number, that whose aliquot parts, added together, make the whole number, as 6, 28; the aliquot parts of 6 being 3, 2, and 1=6; and those of 28, being 14, 7, 4, 2, 1,=28.

Imperfect numbers, those whose aliquot parts, added together, make either more or less than the whole. And these are distinguished into abundant and defective; an instance in the former case is 12, whose aliquot parts 6, 4, 3, 2, 1 make sixteen; and in the latter case 16, whose aliquot parts 8, 4, 2, and 1, make but 15.

Plain number, that arising from the multiplication of two numbers, 6, which is the product of 3 by 2; and these numbers are called the sides of the plane.

Square number, is the product of any number multiplied by itself; thus 4, which is the factum of 2 by 2, is a square number.

Every square number added to its root makes an even number.

Polygonal, or polygonous numbers, the sums of arithmetical progressions beginning with unity; these, where the common difference is 1, are called triangular numbers: where 2, square numbers; where 3, pentagonal numbers; where 4, hexagonal numbers; where 5, heptagonal numbers, &c. See POLYGONAL.

Pyramidal numbers: the sums of polygonous numbers, collected after the same manner as the polygons themselves, and not gathered out of arithmetical progressions, are called first pyramidal numbers; the sums of the first pyramidals are called second pyramidals, &c.

If they arise out of triangular numbers, they are called triangular pyramidal numbers; if out of pentagons, first pentagonal pyramidals.

From the manner of summing up polygonal numbers, it is easy to conceive how the prime pyramidal numbers are found, viz. $\frac{(a-2\ n^3+3\ n^2-(a-5)\,n}{6}$ expresses all the prime pyramidals.

NUMBER, in grammar, a modification of nouns, verbs, &c. to accommodate them to the varities in their objects, considered with regard to number.

NUMERAL LETTERS, those letters of the alphabet

NUMERALS, in grammar, those words which express numbers; as six, eight, ten, &c.

NUMERATION. See ARITHMETIC, CHARACTER, &c.

NUMIDA, in ornithology, a genus belonging to the order of gallinæ. On each side of the head there is a kind of coloured fleshy horn; and the beak is furnished with cere near the nostrils. The species called meleagris, or Guinea hen, is a native of Africa. See Plate C. Nat. Hist. fig. 298. It is larger than a common hen. Its body is sloped like that of a partridge; and its colour is all over a dark grey, very beautifully spotted with small white specks; there is a black ring round the neck; its head is reddish, and it is blue under the eyes. They naturally herd together in large numbers, and breed up their young in common; the females taking care of the broods of others, as well as of their own. Barbut informs us, that in Guinea they go in flocks of 200 or 300, perch on trees, and feed on worms and grasshoppers; that they are run down and taken by dogs; and that their flesh is tender and sweet, generally white, though sometimes black. They breed very well with us.

The white-breasted one is a mere variety, of which there are many; it is mostly found in Jamaica. The mitred, or numida mitrata, is a different and not a common species; it inhabits Madagascar and Guinea. The third species which Mr. Latham mentions is the crested, or numida cristata. This species likewise inhabits Africa. Buffon, who describes it at great length, calls it la peintade. Linnæus and Gmelin call it Numida meleagris, &c. Ray and Willughby call it gallus and gallina Guineensis, &c. Mr. Pennant contends, and seems to prove, that the pintados had been early introduced into Britain, at least prior to the year 1277. But they seem to have been much neglected on account of the difficulty of rearing them; for they occur not in our ancient bills of fare. They have a double caruncle at the chaps, and no fold at the throat.

NUNCIO, or *Nuntio*, an ambassador from the pope to some catholic prince or state; or a person who attends on the pope's behalf at a congress, or an assembly of several ambassadors. The nuncio has a jurisdiction and may delegate judges in all the states where he resides, except in France, where he has no authority but that of a simple ambassador. See AMBASSADOR.

NUNCUPATIVE WILL, denotes, a last will or testament, only made verbally, and not put in writing. See WILL and TESTAMENT.

NURSERY, in gardening, is a piece of land set apart for raising and propagating all sorts of trees and plants, to supply the garden and other plantations.

In a nursery for fruit-trees, the following rules are to be observed: 1. That the soil should not be better than that in which the trees are to be planted out for good. 2. That it ought to be fresh, and not such as has been already worn out by trees, or other large growing plants. 3. It ought neither to be too wet, nor too dry, but rather of a middling nature; though, of the two extremes, dry is to be preferred; because, though trees in such a soil do not make so great a progress, yet they are generally sounder, and more disposed to fruitfulness. 4. It must be inclosed in such a manner that neither cattle nor vermin may come in; and so as particularly to exclude hares and rabbits, which, when the ground is covered with snow, are great destroyers of young trees. 5. The ground being inclosed should be carefully trenched about two feet deep; this should be done in August, that it may be ready for receiving young stocks at the season for planting, which is commonly about the beginning of October: in trenching the ground, you must be careful to cleanse it from the roots of all noxious weeds. 6. The season being come for planting, level down the trenches as equal as possible; and then lay out the ground into quarters, which may be laid out in beds for a seminary, in which you may sow the seeds or stones of fruit. 7. And having provided yourself with stocks, the next year proceed to transplant them, in the following manner: draw a line across the ground intended to be planted, and open a number of trenches exactly straight; then take the stocks out of the seed-beds; in doing which, you should raise the ground with a spade, in order to preserve the roots as entire as possible; prune off the very small fibres, and if there are any that have a tendency to root directly downwards, such roots should be shortened. Then plant them in the trenches, if they are designed for standards, in rows three feet and a half, or four feet, from each other, and a foot and a half distant in the rows; but if for dwarfs, three feet row from row, and one foot in the row, will be a sufficient distance. These plants should by no means be headed, or pruned at top, which will weaken them, and cause them to produce lateral branches. If the winter should prove very cold, lay some mulch on the surface of the ground near their roots, taking care not to let it lie too thick near the stems of the plants, and to remove it as soon as the frost is over. In the summer season destroy the weeds, and dig up the ground every spring between the rows. The second year after planting, such of the stocks as are designed for dwarfs will be fit to bud; but those that are designed for standards should be suffered to grow five or six feet high before they are budded or grafted: for the manner of doing which, see GRAFTING.

As to timber trees, Mr. Miller advises those gentlemen who would have plantations in parks, woods, &c. to make nurseries upon the ground intended for planting, where a sufficient number of the trees may be left standing, after the others have been drawn out to plant in other places.

The ground intended for the flower-nursery should be well situated to the sun; and defended from strong winds by plantations of trees, or by buildings. The soil also should be light and dry, especially for bulbous-rooted flowers; for in this nursery the offsets of all bulbous-rooted flowers should be planted, and remain there till they become blowing roots, when they should be removed into the pleasure-garden, and planted either in beds or borders, according to the goodness of the flowers. These flowers may also be raised in the nursery from seed. The seedling auriculas, polyanthuses, ranunculuses, anemonies, carnations, &c. should be raised in this nursery, where they should be preserved till they have flowered, when all those should be marked that are worthy of being transplanted into the flower-garden; this should be done in their proper seasons; for all these seedling flowers ought not indiscriminately to be exposed to public view in the pleasure-garden, because it al

ways happens, that there are great numbers of ordinary flowers produced among them, which will there make but an indifferent appearance.

NUT. See CORYLUS.

NUT-GALLS. See GALLIC ACID.

NUTATION, in astronomy, a kind of tremulous motion of the axis of the earth, whereby, in each annual revolution, it is twice inclined to the ecliptic, and as often returns to its former position. Sir Isaac Newton observes, that the moon has the like motion, only very small, and scarcely sensible.

NUTMEG. See MYRISTICA.

NUTRITION. See DIGESTION, MATERIA MEDICA, and PHYSIOLOGY.

NUX VOMICA, a flat, compressed, round fruit, about the breadth of a shilling, brought from India. See STRYNCHUS.

NYCTANTHES, *Arabian Jasmine*, a genus of the monogynia order, in the diandria class of plants; and in the natural method ranking with the 44th order, sepiariæ. The corolla and calyx are octofid: the perianthium dicoccous. There are seven species, the most remarkable of which are: 1. The arbor tristis, or sorrowful tree. This tree, or shrub, the pariaticu of the Bramins, grows naturally in sandy places in India, particularly in the islands of Ceylon and Java, where it is procured in great abundance, and attains the height of 18 or 20 feet. It rises with a four-cornered stem, bearing leaves that are oval, and taper to a point. The flowers, which are white and highly odoriferous, having a sweet delectable smell emulating the best honey, consist of one petal deeply divided into eight parts, which are narrower towards the stalks, and dilated towards the summit. The fruit is dry, capsular, membranaceous, and compressed.

It is generally asserted of this plant, that the flowers open in the evening, and fall off the succeeding day. Fabricius and Paludanus, however, restrict the assertion, by affirming, from actual observation, that this effect is found to take place only in such flowers as are immediately under the influence of the solar rays. Grimmius remarks in his Laboratorium Ceylonicum, that the flowers of this tree afford a fragrant water, which is cordial, refreshing, and frequently employed with success in inflammations of the eyes. The tube of the flower, when dried, has the smell of saffron; and being pounded and mixed with sanders-wood, is used by the natives of the Malabar coast for imparting a grateful fragrancy to their bodies, which they rub or anoint with the mixture.

2. The angustifolia, of which the flowers are white, inexpressibly fragrant, and generally appear in the warm summer-months. Strong loam is its proper soil.

NYMPH, among naturalists, that state of winged insects between their living in the form of a worm, and their appearing in the winged or most perfect state. See ENTOMOLOGY.

NYMPHÆA. See ANATOMY.

NYMPHÆA, the *water lily*, a genus of the monogynia order, in the polyandria class of plants; and in the natural method ranking under the 54th order, miscellanea. The corolla is polypetalous; the calyx tetraphyllous or pentaphyllous; the berry multilocular and truncated. There are six species, of which the most remarkable are: 1. and 2. The lutea and alba, or yellow and white water-lilies; both of which are natives of Britain, growing in lakes and ditches. Linnæus tells us, that swine are fond of the leaves and roots of the former; and that the smoke of it will drive away crickets and blattæ, or cock-roaches, out of houses. The root of the second has an astringent and bitter taste, like those of most aquatic plants that run deep into the mud. 3. The lotus, with heart-shaped toothed leaves, a plant thought to be peculiar to Egypt, is mentioned by Herodotus. M. Savary metions it as growing in the rivulets and on the sides of the lakes; and that there are two sorts or varieties of the plant, the one with a white, the other with a blueish flower. "The calyx (he says) blows like a large tulip, and diffuses a sweet smell, resembling that of the lily. The first species produces a round root like that of a potatoe; and the inhabitants of the banks of the lake Menzall feed upon it. The rivulets in the environs of Damietta are covered with this majestic flower, which rises upwards of two feet above the water. 4. In the East and West Indies grows a species of this plant, named nelumbo by the inhabitants of Ceylon. The flowers are large, flesh-coloured, and consist of numerous petals, disposed as in the other species of water-lily, in two or more rows. The seed-vessel is shaped like a top, being broad and circular above, narrow and almost pointed below. It is divided into several distinct cells, which form so many large round holes upon the surface of the fruit, each containing a single seed. With the flower of this plant, which is sacred among the heathens, they adorn the alters of their temples. The stalks, which are used as a pot-herb, are of a wonderful length. The root is very long, extends itself transversely, is of the the size of a man's arm, jointed and fibrous, with long intervals between the joints. The fibres surround the joints in verticilli or whorls.

NYSSA, a genus of the order of diœcia, in the polygamia class of plants; and in the natural method ranking under the 12th order, holoraceæ. The hermaphrodite calyx is quinquepartite; there is no corolla; the stamina are five; there is one pistil: the fruit a plum inferior. The calyx is quinquepartite, no corolla, and ten stamina. There are two species: 1. The integrifolia, entire-leaved; and, 2. The denticulata, or serrated-leaved tupelo.

The entire-leaved tupelo-tree, in its native soil and climate, grows to near 20 feet high; in this country its size varies according to the nature of the soil or situation. In a moist rich earth, well sheltered, it comes to near 20 feet; in others, that are less so, it makes slower progress, and in the end is proportionally lower. The branches are not very numerous; and it rises with a regular trunk, at the top of which they generally grow. In England they seldom produce fruit.

The serrated-leaved tupelo-tree grows usually nearly 30 feet in height: and divides into branches near the top like the other. The leaves are oblong, pointed, of a light green colour, and come out without order on long footstalks. The flowers come out from the wings of the leaves on long footstalks. They are small, of a greenish-colour; and are succeeded by oval drupes, containing sharp-pointed nuts, about the size of a French olive.

O.

O, the fourteenth letter of our alphabet. As a numeral, it is sometimes used for eleven; and with a dash over it thus, $\overline{O}$, for eleven thousand. In the notes of the ancients, O. CON. is read opus conductum; O. C. Q. opere consilioque; O. D. M. opera, donum, munus; and O. L. O. opus locatum.

In music, the O, or rather a circle, or double CↃ, is a note of time called by us a semi-breve; and by the Italians circolo. The O is also used as a mark of triple time, as being the most perfect of all figures.

OAK. See QUERCUS.

OAKAM, old ropes untwisted, and pulled out into loose hemp, in order to be used in caulking the seams, tree-nails, and bends of a ship, for stopping or preventing leaks.

OAR, in navigation, a long piece of wood, for moving a vessel by rowing. Oars for ships are generally cut out of fir-timber, those for barges are made out of New England or Dantzic-rafters, and those for boats, either out of English ash, or fir rafters from Norway.

OAT. See AVENA.

OATH, an affirmation or denial of any thing before one or more persons, who have the authority to administer the same, for the discovery and advancement of truth and right. See AFFIDAVIT.

OBELISK, a truncated quadrangular, and slender pyramid, raised as an ornament, and frequently charged either with inscriptions or hieroglyphics.

Obelisks appear to be of very great antiquity, and to be first raised to transmit to posterity precepts of philosophy, which were cut in hieroglyhical characters: afterwards they were used to immortalize the great actions of heroes, and the memory of persons beloved. The first obelisk mentioned in history was that of Rameses king of Egypt, in the time of the Trojan war, which was forty cubits high. Phius, another king of Egypt, raised one of forty-five cubits; and Ptolomy Philadelphus, another of eighty-eight cubits, in memory of Arsinoe. Augustus erected one at Rome in the Campus Martius, which served to mark the hours on an horizontal dial, drawn on the pavement. They were called by the Egyptian priests the fingers of the sun, because they were made in Egypt also, to serve as styles or gnomons to mark the hours on the ground. The Arabs still call them Pharoah's needles, whence the Italians call them aguglia, and the French aiguilles.

The proportions in the height and thickness are nearly the same in all obelisks; their height being nine or nine and a half, and sometimes ten times, their thickness; and their diameter at the top never less than half, and never greater than three-fourths, of that at the bottom.

OBLATE, flatted, or shortened; as an oblate spheroid, having its axis shorter than its middle diameter, being formed by the rotation of an ellipse about the shorter axis.

OBLATENESS. See EARTH, figure of.

OBLIGATION, a bond containing a penalty, with a condition annexed, either for payment of money, performance of covenants, or the like. This security is called a specialty. Co. Lit. 172. See BOND, and DEED.

OBLIQUE, in geometry, something aslant, or that deviates from the perpendicular. Thus, an oblique angle, is either an acute or obtuse one; that is, any angle except a right one.

OBLIQUE PLANES. See DIALLING.

OBLONGATA MEDULLA. See ANATOMY.

OBOLUS, in antiquity, an ancient Athenian coin, worth a penny farthing. Among ancient physicians, obolus likewise denoted a weight, equal to ten grains.

OBOLARIA, a genus of the angiospermia order, in the didynamia class of plants; and in the natural method ranking under the 40th order, personatæ. The calyx is bifid; the corolla campanulated and quadrifid; the capsule unilocular, bivalved, and polyspermous; the stamina rising from the divisions of the corolla. There is one species, a herb of Virginia.

OBSERVATORY, a place destined for observing the heavenly bodies; being generally a building erected on some eminence, covered with a terrace for making astronomical observations.

The principal instruments for a fixed observatory are, a large fixed quadrant, or a circular divided instrument, chiefly for measuring vertical angles; a transit instrument; an equatorial instrument; a chronometer, or regulator; one or more powerful telescopes; a fixed zenith telescope, and a night telescope.

The quadrant, or quarter of a circle, divided into 90°, and each degree subdivided into minutes or smaller parts, has been made of various sizes; some of them having a radius even of eight or nine or more feet in length. When those quadrants do not exceed one or two, or at most three feet, in radius, they are generally fixed upon their particular stands, which are furnished with various mechanical contrivances, that are necessary to place the plane of the quadrant perpendicular to the horizon, and for all the other necessary adjustments. But large quadrants are fixed upon a strong wall by means of proper clamps; hence they have been commonly called mural quadrants, and are situated in the plane of the meridian of the observatory. In either of those quadrants an index, which reaches from the centre to the edge of the arch, moves round that centre, or round a short axis which passes through that centre so as to be moveable with its extremity all round that arc, and thus point out on the divisions of the arch, the angle which it forms with the horizon, or with the vertical line, in any given situation. This index carries a telescope, through which the observer looks at any particular object, whose altitude he wishes to determine.

Plate XCV. Observatory, &c. fig. 1. represents a simple construction of a small moveable quadrant, and fig. 2. represents a mural quadrant. Of the quadrant fig. 1. CE B is the arch divided into 90°, and generally subdivided into smaller divisions, such as half degrees, or third parts of each degree, &c. The centre of the arch is at A, and the whole is connected together by means of strong me-

tallic bars, as is shown between the letters ABC in the figure: in the centre A, a short axis is fixed perpendicular to the plane of the instrument, and to the upper part of this axis is fastened the index AD, which carries the telescope. This index generally has a small lateral projection, as at E, upon which the nonius or vernier is marked, by which means the minutes or smaller parts of each degree may be discerned. (See VERNIER.) The screw P, commonly called the tangent screw, with a nut that may be fastened to any part of the arch BC, screws likewise into the extremity of the index, and is useful for moving the index gently, or more accurately than by the immediate application of the hand to the index itself.

Since the index is suspended at one end, viz. at A, if the other end D happens to be disengaged from the screw P, the lower end D of the index will naturally come down to C, on account of its own weight, and that of the telescope. Now, in order to avoid this tendency downwards, an arm Y of brass or iron, is frequently affixed to the upper part of the index, which carries the leaden weight Z, sufficient to balance the weight of the index and telescope; so that by this means, even when disengaged from the screw P, the index will remain in any situation in which it may be left. The whole frame ABC is supported upon a strong vertical axis FS, the lower part of which turns into the pedestal OK*m*, and carries an index SX, which moves upon the divided horizontal circle O, fixed to the pedestal. This serves to fix the plane of the quadrant in any azimuth that may be required. The lower part of the pedestal has three claws, with a screw *m* in each; by which means the axis FS may be set truly perpendicular. The plummet AO, suspended at A, serves to show when the edge AC of the instrument is truly perpendicular, or when the first division of the arch at C is exactly in the vertical which passes through the centre A of the quadrantal arc BC. The weight of the plummet generally moves in a glass of water, which is fixed upon the arm GR; the object of which is to check the vibrations of the pendulum; which otherwise would be easily moved by every breath of air, and would continue to move for a considerable time after. We do not mention the lenses or microscopes that are applied to read off the divisions at E and at X, or to see the coincidence of the plummet-line with a dot marked upon the arc at C, as matters that need no particular description.

In the eye-tube of the telescope AD, there are certain slender wires, placed in the focus of the eye-lens, and perpendicular to the axis of the telescope, which enable the observer to distinguish more accurately when an object, that is seen through the telescope, reaches the axis of the telescope, or, as it is more commonly called, the line of collimation, &c. Now when the stars or planets are observed at night, those wires in the eye-tube cannot be seen; therefore, to render them visible, an arm or wire is fixed occasionally at the end of the telescope, which arm holds a small piece of ivory or card *z*, set aslant to the axis of the telescope; for when a lighted candle or lantern is situated at a little distance, and is directed so as to shine upon the above-mentioned ivory or card, the reflection of the light from it into the tube of the telescope will enable the observer to distinguish the wires at the same time that he beholds the celestial object.

The mural quadrant, fig. 2, is a larger instrument like the above, excepting that it has no stand; and its index is prevented from bending on account of its great length, by means of metallic bars, *d. f, b. c.* This instrument is firmly fixed upon a wall exactly in the plane of the meridian of the observatory, for which purpose it has clamps, screws, and other adjustments. It has likewise a plummet,

This undoubtedly is the principal instrument of an observatory; for by observing the times by the clock, of the arrival of any celestial object to the meridian, the right ascension of that object is had immediately; and its declination is shown at the same time by the index of the quadrant upon the divided arch; deducting the inclination of the equator, which is given by the latitude once ascertained of the observatory. It is by this means that exact catalogues of the places of the fixed stars have been made.

The transit instrument consists of a telescope of any convenient length, fixed at right angles to a horizontal axis, which axis is supported at its two extremities; and the instrument is generally situated so that the line of collimation of the telescope may move in the plane of the meridian. The use of this instrument is to observe the precise time of the celestial bodies' passage across the meridian of the observatory.

Fig. 3. exhibits a transit instrument. NM is the telescope; in the eye-tube of which a system of parallel wires, is situated in the focus of the eye-lens. FE is the horizontal axis, in the middle of which the telescope is steadily fixed; so that by moving the telescope, the axis is forced to turn round its two extremities E and F, which rest in the notches of two thick pieces, T, S, of bell-metal, such as are delineated separately and magnified at X and Z. Those pieces are generally fixed upon two pillars, either of cast iron, or, which is better, of stone, as are shown in the figure; and they are constructed so as to be susceptible of a small motion by means of slides and screws, viz. the piece T backwards and forwards, and the piece S upwards and downwards; by which means the axis EF of the instrument may be set exactly horizontal, and caused to move perpendicular to the plane of the meridian. In order to verify the first of those requisites, viz. to see whether the axis is truly horizontal, the long spirit-level P Q is suspended upon it by means of the metallic branches PO and QR; and the situation of the bubble in it will immediately show whether the axis is truly horizontal, or which way it inclines, and of course where it must be raised or depressed. The other requisite, viz. whether the axis is perpendicular to the plane of the meridian, or not, may be verified by various means, the best of which is by observations on those circumpolar stars which never go below the horizon of the observatory. Thus, observe the times by the clock, when a circumpolar star, seen through the telescope NM, crossess the meridian both above and below the pole; and if the times of describing the eastern and western parts of its circuit are equal, the telescope is then in the plane of the meridian, consequently the axis EF is perpendicular to that plane; otherwise the notched pieces T and S, which support the extremities E, F. of the axis, must be moved accordingly, or until upon observation it is found

that the above-mentioned times of the stars' semi-revolutions are equal.

When the instrument has been once so adjusted, a mark may be made upon a house, or rock, or post, at some distance from the observatory, so that when viewed through the telescope, this mark may appear to be in the direction of the axis of the telescope; by which means the correct situation of the instrument may afterwards be readily verified.

The cylindric extremity F is perforated, and the perforation passes through the half of the axis, and reaches the inside of the telescope; that side of the telescope tube which is exactly facing F, being also perforated. Within the said tube, and directly opposite to the perforation of the end F, a plane reflector, or a flat piece of ivory, is fixed, making an angle of 45° with the axis of the telescope, and having a hole through it large enough to admit all the rays passing from the object-glass to the eye-glass of the telescope.

When stars or other celestial objects are to be observed in the night-time, a small lantern Y is set upon a stand just before the perforation of the extremity F, so as to throw the light within the axis, and upon the slant reflector within the tube of the telescope, whence it is reflected upon the wires in the eye-tube M, and renders them visible. By placing the lantern nearer to, or farther from, the extremity F, the observer may illuminate the wires sufficiently for the purpose, and not too much.

To the other extremity E of the axis, a divided circle, or sometimes a semicircle, is fixed, which turns with the axis; the index being fixed to the pillar which supports the axis. Sometimes the situation of those parts is reversed, viz. the circle is fastened to the pillar, or to the brass piece which supports the axis, and the index is fastened to the extremity E of the axis. The use of this circle, is to place the telescope in the direction of any particular celestial body, when that body crosses the meridian; which inclination is equal to the co-latitude of the place, more or less the declination of the celestial body, according as that declination is north or south.

To adjust the clock by the sun's transit over the meridian.—Note the times by the clock when the preceding and following edges of the sun's limb touch the cross wires. The difference between the middle time and 12 hours, shows how much the mean, or time by the clock, is faster or slower than the apparent, or solar time, for that day; to which the equation of time being applied, will show the time of mean noon for that day, by which the clock may be adjusted.

Astronomical or equatorial sector, an instrument for finding the difference in right ascension and declination between two objects, the distance of which is too great to be observed by the micrometer, was invented by Graham. Let AB (fig. 4.) represent an arch of a circle, containing 10 or 12 degress well divided, having a strong plate CD for its radius, fixed to the middle of the arch at D: let this radius be applied to the side of an axis HFI, and be moveable about a joint fixed to it at F, so that the plane of the sector may be always parallel to the axis H I; which being parallel to the axis of the earth, the plane of the sector will always be parallel to the plane of some hour-circle. Let a telescope CE be moveable about the centre C of the arch AB, from one end of it to the other, by turning a screw at G; and let the line of sight be parallel to the plane of the sector. Now, by turning the whole instrument about the axis HI, till the plane of it is successively directed, first to one of the stars and then to another, it is easy to move the sector about the joint F, into such a position, that the arch AB, when fixed shall take in both the stars in their passage, by the plane of it, provided the difference of their declinations does not exceed the arch AB. Then, having fixed the plane of the sector a little to the westward of both the stars, move the telescope CE by the screw G; and observe by a clock the time of each transit over the cross hairs, and also the degrees and minutes upon the arch AB cut by the index at each transit; then in the difference of the arches, the difference of the declinations, and by the difference of the times, we have the difference of the right ascensions of the stars.

The dimensions of this instrument are these: The length of the telescope, or the radius of the sector, is $2\frac{1}{2}$ feet; the breadth of the radius, near the end C, is $1\frac{1}{2}$ inch; and at the end D two inches. The breadth of the limb AB is $1\frac{1}{2}$ inch; and its length six inches, containing ten degrees divided into quarters, and numbered from each end to the other. The telescope carries a nonius or subdividing plate, whose length, being equal to sixteen quarters of a degree, is divided into fifteen equal parts; which, in effect, divides the limb into minutes, and, by estimation, into smaller parts. The length of the square axis HFI is eighteen inches, and its thickness is about a quarter of an inch: the diameters of the circles are each 5 inches; the thickness of the plates, and the other measures, may be taken at the direction of a workman.

This instrument may be rectified, for making observations, in this manner: By placing the intersection of the cross hairs at the same distance from the plane of the sector, as the centre of the object-class, the plane described by the line of sight during the circular motion of the telescope upon the limb will be sufficiently true, or free from conical curvity: which may be examined by suspending a long plumb-line at a convenient distance from the instrument; and by fixing the plane of the sector in a vertical position, and then by observing, while the telescope is moved by the screw along the limb, whether the cross hairs appear to move along the plumb-line.

The axis *h f o* (see figure below) may be elevated nearly parallel to the axis of the earth, by means of a small common quadrant; and its error may be corrected by making the line of sight follow the circular motion of any of the circumpolar stars, while the whole instrument is moved about its axis *h f o*, the telescope being fixed to the limb; for this purpose, let the telescope *k l* be directed to the star *a*, when it passes over the highest point of its diurnal circle, and let the division cut by the nonius be then noted: then after twelve hours, when the star comes to the lowest point of its circle, having turned the instrument half-round its axis to bring the telescope into the position *m n*; if the cross hairs cover the same star supposed at *b*, the elevation of the axis *h f o* is exactly right; but if it is necessary to move the telescope into the position *u v*, in order to point to this star at *c*, the arch *m u*, which measures the angle *m f u* or *b f c*, will be known; and then the axis *h f o* must be depressed half the quanti-

ty of this given angle if the star passed below *b*, or must be raised so much higher if above it; and thus the trial must be repeated till the true elevation of the axis is obtained. By making the like observations upon the same star on each side the pole, in the six o'clock hour-circle, the error of the axis, towards the east or west, may also be found and corrected, till the cross-hairs follow the star quite round the pole: for supposing *a o p b c* to be an arch of the meridian, make the angle *a f p* equal to half the angle *a f c*, and the line *f p* will point to the pole; and the angle *o f p*, which is the error of the axis, will be equal to half the angle *b f c*, or *m f u*, found by the observation; because the difference of the two angles *a f b*, *a f c*, is double the difference of their halves *a f o* and *a f p*. Unless the star is very near the pole, allowance must be made for refractions.

Equatorial or portable observatory: an instrument designed to answer a number of useful purposes in practical astronomy, independantly of any particular observatory; it may be made use of in any steady room and performs most of the useful problems in the science.

The principal parts of this instrument (fig. 5.) are, 1. The azimuth or horizontal circle A, which represents the horizon of the place, and moves on an axis B, called the vertical axis. 2. The equatorial or hour circle C, representing the equator, placed at right angles to the polar axis D, or the axis of the earth, upon which it moves. 3. The semicircle of declination E, on which the telescope is placed, and moving on the axis of declination, or the axis of motion of the line of collimation F. These circles are measured and divided as in the following table:

Measures of the several circles, and divisions on them.	Radius in dec.	Limb divided to	Nonius of 30 gives seconds.	Divided on limb into parts of inc.	Divided by nonius into parts of inc.
Azimuth, or horizontal circle	5 1	15′	30″	45th	1350th
Equatorial, or hour circle	5 1	15′ / 1′ in time	30′ / 2″	45th	1350th
Vertical semi-circle, for declination or latitude.	5 5	15′	30″	45th	1260th

4. The telescope in this equatorial may be brought parallel to the polar axis, as in the figure, so as to point to the pole-star in any part of its diurnal revolution; and thus it has been observed near noon, when the sun has shone very bright. 5. The apparatus for correcting the error in altitude occasioned by refraction, which is applied to the eye-end of the telescope, and consists of a slide G moving in a groove or dovetail, and carrying the several eye-tubes of the telescope, on which slide there is an index corresponding to 5 small divisions engraved on the dovetail; a small circle called the refraction circle, H, moveable by a finger-screw at the extremity of the eye-end of the telescope; which circle is divided into half-minutes, one entire revolution of it being equal to 3′ 18″, and by its motion raises the centre of the cross hairs on a circle of altitude, and likewise a quadrant I of an inch and a half radius, with divisions on each side, one expressing the degree of altitude of the object viewed, and the other expressing the minutes and seconds of error occasioned by refraction, corresponding to that degree of altitude: to this quadrant is joined a small round level K, which is adjusted partly by the pinion that turns the whole of this apparatus, and partly by the index of the quadrant; for which purpose the refraction-circle is set to the same minute, &c. which the index points to on the limb of the quadrant; and if the minute, &c. given by the quadrant exceeds the 3′ 18″ contained in one entire revolution of the refraction-circle, this must be set to the excess above one or more of its entire revolutions; then the centre of the cross hairs will appear to be raised on a circle of altitude to the additional height which the error of refraction will occasion at that altitude.

The principal adjustment in this instrument is that of making the line of collimation to describe the portion of an hour-circle in the heavens; in order to which, the azimuth-circle must be truly level; the line of collimation, or some corresponding line represented by the small brass rod M parallel to it, must be perpendicular to the axis of its own proper motion; and this last axis must be perpendicular to the polar axis. On the brass rod M there is occasionally placed a hanging level N, the use of which will appear in the following adjustments.

The azimuth-circle may be made level by turning the instrument till one of the levels is parallel to an imaginary line joining two of the feet-screws; then adjust that level with these two feet-screws; turn the circle half round, that is, 180°; and if the bubble is not then right, correct half the error by the screw belonging to the level, and the other half error by the two feet-screws; repeat this till the bubble comes right; then turn the circle 90° from the two former positions, and set the bubble right; if it is wrong, by the foot-screw at the end of the level; when this is done, adjust the other level by its own screw, and the azimuth-circle will be truly level. The hanging level must then be fixed to the brass rod by two hooks of equal length, and made truly parallel to it: for this purpose make the polar axis perpendicular, or nearly perpendicular, to the horizon; then adjust the level by the pinion of the declination-semicircle, reverse the level, and if it is wrong, correct half the error by a small steel screw that lies under one end of the level, and the other half error by the pinion of the declination-semicircle; repeat this till the bubble is right in both positions. In order to make

the brass rod on which the level is suspended, at right angles to the axis of motion of the telescope or line of collimation, make the polar axis horizontal, or nearly so; set the declination-semicircle to 0°, turn the hour-circle till the bubble comes right; then turn the declination-circle to 90°; adjust the bubble by raising or depressing the polar axis, (first by hand till it is nearly right, afterwards tighten with an ivory-key the socket which runs on the arch with the polar axis, and then apply the same ivory key to the adjusting-screw at the end of the said arch till the bubble comes quite right); then turn the declination-circle to the opposite 90°; if the level is not then right, correct half the error by the aforesaid adjusting screw at the end of the arch, and the other half error by the two screws which raise or depress the end of the brass rod. The polar axis remaining nearly horizontal as before, and the declination-semicircle at 0°, adjust the bubble by the hour-circle; then turn the declination-semicircle to 90°, and adjust the bubble by raising or depressing the polar axis; then turn the hour-circle 12 hours; and if the bubble is wrong, correct half the error by the polar axis, and the other half-error by the two pair of capstan-screws at the feet of the two supports on one side of the axis of motion of the telescope; and thus this axis will be at right angles to the polar axis. The next adjustment is to make the centre of cross hairs remain on the same object, while you turn the eye-tube quite round by the pinion of the refraction apparatus: for this adjustment, set the index on the slide to the first division of the dovetail; and set the division marked 18″ on the refraction-circle to its index; then look through the telescope, and with the pinion turn the eye-tube quite round; and if the centre of the hairs does not remain on the same spot during that revolution, it must be corrected by the four small screws, two and two at a time (which you will find upon unscrewing the nearest end of the eye-tube that contains the first eye-glass); repeat this correction till the centre of the hairs remains on the spot you are looking at during an entire revolution. In order to make the line of collimation parallel to the brass rod on which the level hangs, set the polar axis horizontal, and the declination-circle to 90°; adjust the level by the polar axis; look through the telescope on some distant horizontal object covered by the centre of the cross hairs; then invert the telescope: which is done by turning the hour circle half-round; and if the centre of the cross hairs does not cover the same object as before, correct half the error by the uppermost and lowermost of the four small screws at the eye-end of the large tube of the telescope: this correction will give a second object now covered by the centre of the hairs, which must be adopted instead of the first object: then invert the telescope as before; and if the second object is not covered by the centre of the hairs, correct half the error by the same two screws which were used before: this correction will give a third object, now covered by the centre of the hairs, which must be adopted instead of the second object; repeat this operation till no error remains; then set the hour-circle exactly to 12 hours (the declination-circle remaining at 90 degrees as before); and if the centre of the cross hairs does not cover the last object fixed on, set it to that object by the two remaining small screws at the eye-end of the large tube, and then the line of collimation will be parallel to the brass rod. For rectifying the nonius of the declination and equatorial circles, lower the telescope as many degrees, minutes, and seconds, below 0° or Æ on the declination-semicircle, as are equal to the complement of the latitude, then elevate the polar axis till the bubble is horizontal, and thus the equatorial circle will be elevated to the co-latitude of the place; set this circle to 6 hours: adjust the level by the pinion of the declination-circle: then turn the equatorial circle exactly 12 hours from the last position; and if the level is not right, correct one half of the error by the equatorial circle, and the other half by the declination-circle; then turn the equatorial circle back again exactly 12 hours from the last position; and if the level is still wrong, repeat the correction as before till it is right when turned to either position; that being done, set the nonius of the equatorial circle exactly to 6 hours, and the nonius of the declination circle exactly to 0°.

The principal uses of this equatorial are,

1. To find the meridian by one observation only: for this purpose elevate the equatorial circle to the co-latitude of the place, and set the declination-semicircle to the sun's declination for the day and hour of the day required; then move the azimuth and hour circle both at the same time, either in the same or contrary directions, till you bring the centre of the cross hairs in the telescope exactly to cover the centre of the sun; when that is done, the index of the hour-circle will give the apparent or solar time at the instant of observation; and thus the time is gained, though the sun is at a distance from the meridian; then turn the hour-circle till the index points precisely at 12 o'clock, and lower the telescope to the horizon, in order to observe some point there in the centre of your glass, and that point is your meridian mark found by one observation only; the best time for this operation is three hours before or three hours after 12 at noon.

2. To point the telescope on a star, though not on the meridian, in full day-light. Having elevated the equatorial circle to the co-latitude of the place, and set the declination-semicircle to the star's declination, move the index of the hour-circle till it shall point to the precise time at which the star is then distant from the meridian, found in tables of the right ascension of the stars, and the star will then appear in the glass. Besides these uses peculiar to this instrument, it is also applicable to all the purposes to which the principal astronomical instruments, viz. a transit, a quadrant, and an equal-altitude instrument, are applied.

Of all the different sorts of chronometers or timekeepers, a pendulum-clock, when properly constructed, is undoubtedly capable of the greatest accuracy, it being liable to fewer causes of obstruction or irregularity; therefore such machines are most recommendable for an observatory. The situation of this clock must be near the quadrant, and near the transit instrument; so that the observer, whilst looking through the telescope of any of those instruments, may hear the beats of the clock and count the seconds.

We need hardly observe with respect to the telescopes, that they are of very great use in an observatory. Indeed a telescope for the same can never be too good or

too large; and it should be furnished with micrometers, with different eye-pieces, &c.; but as a large instrument of that sort is not easily managed, nor is always required, so there should be two or three telescopes of different sizes and different powers in every observatory. One at least ought to be fixed upon an axis which may move parallel to the axis of the earth; for in this construction the celestial bodies may, with the telescope, be easily followed in their movements; as the hand of the observer is, in that case, obliged to move the telescope in one direction only.

A pretty good telescope placed truly vertically in an observatory, is likewise a very useful instrument; as the aberration of the stars, latitude of the place, &c. may be observed and determined by the use of such an instrument, with great ease and accuracy.

The night telescope is a short telescope, which magnifies very little; but it collects a considerable quantity of light, and has a very great field of view; it therefore renders visible several dim objects, which cannot be discovered with telescopes of considerably greater magnifying powers; and hence it is very useful for finding out nebulæ, or small comets, or to see the arrangement of a great number of stars in one view.

The principal instruments that are at present used for marine astronomy, or for the purposes of navigation, are that incomparably useful instrument called Hadley's sextant, or quadrant, or octant; a portable chronometer; and a pretty good telescope. With these few instruments, the latitudes, longitudes, hours of the day or night, and several other problems useful to navigators, may be accurately solved. See OPTICS, and QUADRANTS.

OBSIDIAN, in mineralogy, called also the Iceland agate, is found either in detached masses, or forming a part of rocks. It has the appearance of black glass. It is usually invested with a grey or opaque crust. Its fracture is conchoidal. Specific gravity 2.35 nearly. Colour black, or greyish-black; when in very thin pieces green. Very brittle. It melts into an opaque grey mass. It is composed of

69	silica
22	alumina
9	iron
100.	

OBTURATOR. See ANATOMY.

OCCIPITALES. See ANATOMY.

OCCULT, in geometry, is used for a line that is scarcely perceptible, drawn with the point of the compass, or a leaden pencil. These lines are used in several operations, as the raising of plans, designs of buildings, pieces of perspective, &c. They are to be effaced when the work is finished.

OCCULTATION, *circle of perpetual*, is a parallel in an oblique sphere, as far distant from the depressed pole, as the elevated pole is from the horizon. All the stars between this parallel and the depressed pole, never rise, but lie constantly hid under the horizon of the place.

OCCUPATION, or OCCUPANCY. The law of occupancy is founded upon the law of nature, and is simply the taking possession of those things, which before belonged to nobody; and this is the true ground and foundation of all property. In the civil law it denotes the possession of such things as at present properly belong to no private person, but are capable of being made so; as by seizing or taking of spoils in war, by catching things wild by nature, as birds and beasts of game, &c, or by finding things before undiscovered, or lost by their proper owners.

OCCUPIERS *of walling*, a term in the salt-works for the persons who are the sworn officers that allot, in particular places, what quantity of salt is to be made, that the markets may not be overstocked, and see that all is carried fairly and equally between the lord and the tenant.

OCEAN, in geography, that vast collection of salt and navigable waters, in which the two continents, the first including Europe, Asia, and Africa, and the last America, are inclosed like islands. The ocean is distinguished into three grand divisions: 1. The Atlantic ocean, which divides Europe and Africa from America, which is generally about three thousand miles wide; 2. The Pacific ocean, or South-sea, which divides America from Asia, and is generally about ten thousand miles over; and, 3. The Indian ocean, which separates the East Indies from Africa, which is three thousand miles over. The other seas which are called oceans, are only parts or branches of these, and usually receive their names from the countries they border upon.

OCHNA, a genus of the monogynia order, in the polyandria class of plants; and in the natural method ranking with those of which the order is doubtful. The corolla is pentapetalous; the calyx pentaphyllous; the berries monospermous, and affixed to a large roundish receptacle. There are three species, trees of the East Indies and South America.

OCHRE, in natural history, a genus of earths, slightly coherent, and composed of fine, smooth, soft, argillaceous particles, rough to the touch, and readily diffusible in water. It is a combination of alumina and red oxide of iron. Ochres are of various colours, as red, blue, yellow, brown, green, &c.

OCHROMA, a genus of the pentandria order, in the monadelphia class of plants; and in the natural method ranking under the 37th order, columniferæ. The corolla consists of six petals, three of which are external, and the other three internal; the antheræ unite, and form a spiral pillar round the style; the capsule is long, and has five loculaments, which contain a number of black round seeds. Of this there is only one species, viz. the ochromo lagopus, the down-tree, or cork-wood. This tree is frequent in Jamaica, is of speedy growth, and rises to about 25 or 30 feet. The flowers are large and yellow. The capsules are about five inches long, rounded, and covered with a thin skin; which when dry falls off in five longitudinal segments, and leaves the fruit greatly resembling a hare's foot. The down is short, soft, and silky; it is used sometimes to stuff beds and pillows; but, like other vegetable downs, is apt to get into clots: an insipid clear gum exudes from the tree when wounded. The bark is tough, and its fibres are in a reticulated form; it might be made into ropes. The dried wood is so very light and buoyant, as to be used by the fishermen in Jamaica for their nets instead of pieces of cork.

OCHROXYLUM, a genus of the class and order pentandria trigynia. The calyx is five-cleft; petals five; nect.

angular, three-lobed, gland.; capsules three, approximately, one-celled, two-seeded.

OCIMUM, or OCYMUM, basil, a genus of the didynamia gymnospermia class of plants, with a bilabiated cup; its flower is monopetalous and ringent; and its seeds, which are four in number, are contained in the cup, which closes for that purpose. There are 25 species. Both the herbs and seed of basil are used in medicine, and are said to be good in disorders of the lungs, and to promote the menses.

OCTAGON, or OCTOGON, in geometry, is a figure of eight sides and angles; and this, when all the sides and angles are equal, is called a regular octagon, or one which may be inscribed in a circle. If the radius of a circle circumscribing a regular octagon is $= r$, and the side of the octagon $= y$; then $y = \sqrt{2r^3 - r\sqrt{2^2}}$.

OCTAGON, in fortification, denotes a place that has eight bastions.

OCTAHEDRON, or OCTAEDRON, in geometry, one of the five regular bodies, consisting of eight equal and equilateral triangles. The square of the side of the octahedron is to the square of the diameter of the circumscribing sphere, as 1 to 2. If the diameter of the sphere is 2, the solidity of the octahedron inscribed in it will be 1,33333 nearly. The octahedron is two pyramids put together at their bases; therefore its solidity may be found by multiplying the quadrangular base of either of them, by one-third of the perpendicular height of one of them, and then doubling the product.

OCTANDRIA, the eighth class in Linnæus's sexual system; consisting of plants with hermaphrodite flowers, which are furnished with eight stamina, or male organs of generation. See BOTANY.

OCTANT, or OCTILE, in astronomy, that aspect of two planets, wherein they are distant an eighth part of a circle, or 45°, from each other.

OCTAVE, in music, an interval containing seven degrees, or twelve semitones, and which is the first of the consonances, in the order of generation. The most simple perception that we can have of two sounds is that of unisons, which, resulting from equal vibrations, are as one to one; the next to this in simplicity is the octave, which is in double computation as one to two. The harmonics of these sounds have a perfect agreement, which distinguishes them from any other interval, and contributes to give them that unisonous effect which induces the common ear to confound them, and take them indifferently one for the other. This interval is called an octave, because moving diatonically from one term to the other, we produce eight different sounds. The octave comprehends all the primitive and original sounds; so that having established a system, or series of sounds, in the extent of an octave, we can only prolong that series by repeating the same order in a second octave, and again in a third, and so on, in all which we shall not find any sound that is not the replicate of some sound in the adjoining octave.

The complete and rigorous system of the octave requires three major tones, two minor, and two major semitones. The temperated system is of five equal tones, and two semitones, forming together seven diatonic degrees.

ODE. See POETRY.

ODONTOGNATHUS, a genus of fishes of the order apodes. The generic character is, mouth furnished with a strong moveable lamina or process on each side the upper jaw; gill-membrane five-rayed.

Aculeated odontognathus. The genus odontognathus consists of a single species, of which the following is the description. The head, body and tail, are very compressed; the lower jaw, which is longer than the upper, is very much elevated towards the other when the mouth is closed, insomuch as to appear almost vertical; and is lowered somewhat in the manner of a drawbridge when the mouth is opened, when it appears like a small scaly boat, very transparent, furrowed beneath, and finely denticulated on the margins; this lower jaw, in the act of depression, draws forwards two flat, irregular laminæ, of a scaly substance, a little bent at their posterior end, and larger at their origin than at their tips, denticulated on their anterior margin, and attached, one on one side and the other on the opposite, to the most prominent part of the upper jaw; when the mouth is closed again, these pieces apply themselves on each side to one of the opercula, of which they represent the exterior denticulated border; in the middle of these jaws is placed the tongue, which is pointed and free in its movements; the gill-covers, which are composed of several pieces, are very transparent at the hind part, but scaly and of a bright silver-colour in front; the gill-membrane is also silvery, and has five rays; the breast is terminated below by a sharp carina furnished with eight crooked spines; the carina of the belly is also furnished with twenty-eight spines, disposed in two longitudinal ranges; the anal fin is very long, and extends almost as far as the base of the tail-fin, which is of a forked shape; the dorsal fin is placed on the tail, properly speaking, at about three quarters of the whole length of the animal, but it is extremely small. The general length of this fish is three decimetres, and its colour, so far as may be conjectured from specimens preserved for some time in spirits, is a bright silver. It is a native of the American seas, and is common about the coasts of Cayenne, where it ranks in the number of edible fishes.

OECONOMY, *animal*, comprehends the various operations of nature, in the generation, nutrition, and preservation of animals. See ANATOMY, PHYSIOLOGY, COMPARATIVE ANATOMY, DIGESTION, &c.

OEDEMA. See SURGERY.

OEDERA, a genus of the syngenesia polygamia segregata class and order; the calyx many-flowered; corollets tubular, hermaphrodite, with one or two female ligulale florets: recep. chaffy, down of several chaffs. There are two species, herbs of the Cape.

OENANTHE, water (or hemlock) drop-wort: a genus of the digynia order, in the pentandria class of plants; and in the natural method ranking under the 45th order, umbellatæ. The florets are difform; these of the disc sessile and barren; the fruit crowned with the calyx. There are 11 species, of which the most remarkable is the crocata, or hemlock dropwort, growing frequently on the banks of ditches, rivers, and lakes, in many parts of Britain. The roots and leaves of this plant are a strong poison; several persons have perished by eating it through mistake, either for water-parsnips or for ce-

lery, which last it much resembles in its leaves. So exceedingly deleterious is this plant, that Mr. Lightfoot tells us he has heard the late Mr. Christopher d'Ehret, the celebrated botanic painter say, that while he was drawing it, the smell or effluvia rendered him so giddy, that he was several times obliged to quit the room, and walk out in the fresh air to recover himself; but recollecting at last what might be the probable cause of his repeated illness, he opened the door and windows of the room, and the free air then enabled him to finish his work without any more returns of the giddiness. Mr. Lightfoot informs us, that he has given a spoonful of the uice of this plant to a dog, but without any other effect than that of making him very sick and stupid. In about an hour he recovered; and our author has seen a goat eat it with impunity. To such of the human species as have unfortunately eaten any part of this plant, a vomit is the best remedy.

Lobel, Ray, and others, call this vegetable œnanthe aquatica cicutæ facie. It grows in great plenty all over Pembrokeshire, and is called by the inhabitants five-fingered root; it is much used by them in cataplasms for the felon or worst kind of whitlow. They eat some parts of it, but carefully avoid the roots or stalks. These indeed are of a most pernicious nature, and never fail to prove instantly fatal unless a proper remedy is applied.

OENOTHERA, TREE-PRIMROSE: a genus of the monogynia order, in the octandria class of plants; and in the natural method ranking under the 17th order, calycanthemæ. The calyx is quadrifid; the petals four; the capsule cylindric beneath; the seeds naked. There are 11 species; the most remarkable of which are: 1. The biennis, or common biennial tree-primrose, with large bright-yellow flowers. 2. Octovalvis, or octovalved, smooth, biennial tree-primrose, with large bright-yellow flowers. 3. The fruticosa, or shrubby narrow-leaved perennial tree-primrose, with clusters of yellow flowers, succeeded by pedicellated acute-angled capsules. 4. The pumila, or low perennial tree-primrose, with bright yellow flowers, succeeded by acute-angled capsules.

These plants are exotics from America; but are all very hardy, prosper in any common soil and situation, and have been long in the English gardens, especially the three first sorts; but the oenothera bienis is the most commonly known.

OESOPHAGUS. See ANOTOMY.

OESTRUS, a genus of insects of the order diptera: the generic character is, antennæ triarticulate, very short, sunk; face broad, depressed, vesicular; mouth, a simple orifice; feelers two, biarticulate, sunk; tail inflected. The genus oestrus or gad-fly is remarkable, like that of ichneumon, for the singular residence of its larvæ, viz. beneath the skin, or in different parts of the bodies of quadrupeds.

The principal European species is the oestrus bovis, or ox-gadfly. This is about the size of a common bee, and is of a pale yellowish-brown colour, with the thorax marked by four longitudinal dusky streaks, and the abdomen by a black bar across the middle, the tip being covered with tawny or orange-coloured hairs; the wings are pale brown and unspotted.

The female of this species, when ready to deposit her eggs, fastens on the back of a heifer or cow, and piercing the skin with the tube situated at the tip of the abdomen, deposits an egg in the puncture; she then proceeds to another spot at some distance from the former, repeating the same operation at intervals on many parts of the animal's back. This operation is not performed without severe pain to the animal on which it is practised; and it is for this reason that cattle are observed to be seized with such violent horror when apprehensive of the approaches of the female oestrus; flying with uncontrolable rapidity, and endeavouring to escape their tormentor by taking refuge in the nearest pond; it being observed that this insect rarely attacks cattle when standing in water.

In the punctures of the skin thus formed by the gadfly, the several eggs hatch; and the larvæ, by their motion and suction, cause so many small swellings or abscesses beneath the skin, which growing gradually larger, become externally visible, exhibiting so many tubercles an inch or more in diameter, with an opening at the top of each, through which may be observed the larva, imbedded in a purulent fluid; its appearance is that of an oval maggot, of a yellowish-white colour while young, but growing gradually darker as it advances in age, till at the time of its full growth it is entirely brown. It is chiefly in the months of August and September that the eggs are laid, and the larvæ remain through the ensuing winter, and till the latter part of the next June, before they are ready to undergo their change into chrysalis. At this period they force themselves out from their respective cells, and falling to the ground, each creeps beneath the first convenient shelter, and laying in an inert state becomes contracted into an oval form, but without casting the larva skin, which dries and hardens round it. When the included insect is ready for exclusion, it forces open the top of the pupa or chrysalis coat, and emerges in its perfect form, having remained within the chrysalis somewhat more than a month.

Though the history of this insect in its larva state has long ago been detailed with sufficient accuracy by Vallisneri, Reaumur, and others, yet the fly itself appears to have been very generally confounded, and that even by Linnæus himself, with a very different species, resembling it in size, but which is bred in the stomach and intestines of horses, the lárvæ being no other than the whitish rough maggots which farriers call by the title of bots. This insect is the oestrus equi; it is a trifle smaller than the oestrus bovis, and is of a yellowish-brown colour, with a dusky band across the thorax, and the tip of the abdomen of similar colour; the wings are whitish, with a pale dusky bar across the middle of each, and two dusky spots at the tip.

The manner in which the young larvæ or bots are introduced into the stomach and bowels of the animal they infest is singularly curious. When the female has been impregnated, and the eggs are sufficiently matured, she seeks among the horses a subject for her purpose, and approaching it on the wing, she holds her body nearly upright in the air, and her tail, which is lengthened for the purpose, curved inwards and upwards; in this way she approaches the part where she designs to deposit her egg; and suspending herself for a few seconds before it, suddenly darts upon it, and leaves her egg adhering to the hair; she hardly appears to settle, but merely touches the hair with the egg held out on the projected point of

the abdomen. The egg is made to adhere by means of a glutinous liquor secreted with it. She then leaves the horse at a small distance, and prepares a second egg, and, poising herself before the part, deposits it in the same way. The liquor dries, and the egg becomes firmly glued to the hair, this is repeated by various flies till four or five hundred eggs are sometimes placed on one horse. The horses, when they become used to this fly, and find that it does them no injury (as the tabani and conopes, by sucking their blood), hardly regard it, and do not appear at all aware of its insidious object. The skin of the horse is always thrown into a tremulous motion on the touch of this insect; which merely arises from the very great irritability of the skin and cutaneous muscles at this season of the year, occasioned by the continued teasing of the flies, till at length these muscles act involuntarily on the slightest touch of any body whatever. The inside of the knee is the part on which these flies are most fond of depositing their eggs, and next to this on the side and back part of the shoulder, and less frequently on the extreme ends of the mane. But it is a fact worthy of attention, that the fly does not place them promiscuously about the body, but constantly on those parts which are most liable to be licked with the tongue: and the ova therefore are always scrupulously placed within its reach; for when they have remained on the hairs four or five days, they become ripe, after which time the slightest application of warmth and moisture is sufficient to bring forth in an instant the latent larva. At this time, if the tongue of the horse touches the egg, its operculum is thrown open, and a small active worm is produced, which readily adheres to the moist surface of the tongue, and is thence conveyed with the food to the stomach.

These larvæ attach themselves to every part of the stomach, but are generally most numerous about the pylorus, and are sometimes, though much less frequently, found in the intestines. Their numbers in the stomach are very various, often not more than half a dozen, at other times more than a hundred, and if some accounts might be relied on, even a much greater number than this. They hang most commonly in clusters, being fixed by the small end to the inner membrane of the stomach, which they adhere to by means of two small hooks or tentacula. When they are removed from the stomach they will attach themselves to any loose membrane, and even to the skin of the hand.

The body of the larva is composed of eleven segments, all of which, except the two last, are surrounded with a double row of horny bristles directed towards the truncated end, and are of a reddish colour, except the points, which are black. These larvæ evidently receive their food at the small end, by a longitudinal aperture, which is situated between two hooks or tentacula. Their food is probably the chyle, which, being nearly pure aliment, may go wholly to the composition of their bodies without any excrementitious residue; though on dissection the intestine is found to contain a yellow or greenish matter, which is derived from the colour of the food, and shows that the chyle, as they receive it, is not perfectly pure.

They attain their full growth about the latter end of May, and are coming from the horse from this time to the latter end of June, or sometimes later. On dropping to the ground they find out some convenient retreat, and change to the chrysalis; and in about six or seven weeks the fly appears.

Oestrus ovis, or the sheep gadfly, is so named from its larva inhabiting the nostrils and frontal sinuses of sheep in particular, though it is also found in similar situations in deer and some other quadrupeds. It is a smaller species than either of the two preceding, and is of a whitish-grey colour, with the thorax marked by four longitudinal black streaks, and the abdomen speckled with black. The larvæ are nearly as large as those of the oestrus equi, and, according to the observations of Mr. Clark, are of a delicate white colour, flat on the under side, and convex on the upper; having no spines at the divisions of the segments, though they are provided with tentacula at the small end. The other is truncated, with a prominent ring or margin. When young these larvæ are perfectly white and transparent: but as they increase in size the upper side becomes marked with two transverse brown lines on each segment, and some spots are seen on the sides. They move with considerable quickness, holding with their tentacula as a fixed point, and drawing up the body towards them. When full-grown they fall through the nostrils, and change to the pupa or chrysalis state, lying on the ground, or adhering to some blade of grass. The fly proceeds from the chrysalis in the space of about two months.

The other British oestri are the oestrus hæmorrhoidalis of Linnæus, whose larva, like that of the oestrus equi, resides in the stomachs of horses; and the oestrus veterinus of Mr. Clark, the larva of which is also found in similar situations. The oestrus hæmorrhoidalis is about the size of a common window-fly, with pale dusky wings, brown thorax, abdomen white at the base, black in the middle, and red at the tip. The oestrus veterinus is nearly of similar size with the oestrus equi, and is entirely of a ferruginous colour, with the abdomen more dusky towards the tip. The oestrus tarandi inhabits Lapland, and deposits its eggs on the back of the reindeer, and is often fatal to them. See Plate C. Nat. Hist. fig. 299.

The other exotic oestri are probably numerous, but are at present very little known.

Whether the formidable African fly, described by Mr. Bruce under the name of zimb or tsaltsalya, may be referred to this genus or not, we shall not pretend to determine; there are however some particulars in its history which would lead one to suppose it an oestrus.

"This insect," says Mr. Bruce, "is a proof how fallacious it is to judge by appearances. If we consider his small size, his weakness, want of variety or beauty, nothing in the creation is more contemptible and insignificant. Yet passing from these to his history, and to the account of his powers, we must confess the very great injustice we do him from want of consideration. We are obliged, with the greatest surprise, to acknowledge, that those huge animals the elephant, the rhinoceros, the lion, and the tiger, inhabiting the same woods, are still vastly his inferiors; and that the appearance of this small insect, nay, his very sound, though he is not seen, occasions more trepidation, movement, and disorder, both in the human and brute creation, than would whole

herds of these monstrous animals collected together, though their number was in a tenfold proportion greater than it really is.

"This insect is called zimb; it has not been described by any naturalist. It is in size very little larger than a bee, and its wings, which are broader than those of a bee, placed separate, like those of a fly. As soon as this plague appears, and their buzzing is heard, all the cattle forsake their food, and run wildly about the plain, till they die, worn out with fatigue, fright, and hunger. No remedy remains for the residents on such spots but to leave the black earth, and hasten down to the sands of Atbara, and there they remain while the rains last, this cruel enemy never daring to pursue them farther.

"What enables the shepherd to perform the long and toilsome journies across Africa is the camel, emphatically called the ship of the desert. Though his size is immense, as is his strength, and his body covered with a thick skin, defended with strong hair, yet still he is not capable to sustain the violent punctures the fly makes with his proboscis. He must lose no time in removing to the sands of Atbara; for when once attacked by this fly, his body, head, and legs, break out into large bosses, which swell, break, and putrify, to the certain destruction of the creature. Even the elephant and rhinoceros, who, by reason of their enormous bulk, and the vast quantity of food and water they daily need, cannot shift to desert and dry places as the season may require, are obliged to roll themselves in mud and mire, which, when dry, coats them over like armour, and enables them to stand their ground against this winged assassin; yet I have found some of these tubercles upon almost every elephant and rhinoceros that I have seen, and attribute them to this cause." There are twelve species of this insect.

OFFENCE, is any act committed against any law. Offences are either capital or not capital. Capital offences are those for which an offender shall lose his life; not capital, where the offender may lose his lands and goods, be fined, or suffer coporeal punishment, or both, but not lose his life. High treason, petit treason, and felony, constitute capital offences; other offences, not capital, include the remaining part of criminal offences or pleas of the crown, and come under the denomination of misdemeanors.

OFFERINGS. Oblations and offerings partake of the nature of tithes; and all persons which, by the laws of this realm, ought to pay their offerings, shall yearly pay to the parson, vicar, proprietary, or their deputies, or farmers of the parishes where they dwell, at such four offering-days as heretofore within the space of four years last past have been accustomed; and in default thereof, shall pay for the said offerings at Easter following. 2 and 3 Ed. VI. c. 13.

OFFICE, is that function, by virtue whereof a person has some employment in the affairs of another. An office is a right to exercise any public or private employment, and to take the fees and emoluments thereunto belonging, whether public as those of magistrates, or private as of bailiffs, receivers, &c.

The statute 5 and 6 Edward VI. c. 16, declares all securities given for the sale of offices unlawful. And if any person shall bargain or sell, or take any reward, or promise of reward, for any office, or the deputation of any office, concerning the revenue, or the keepers of the king's castles, or the administration and execution of justice, unless it is such an office as had been usually granted by the justices of the king's bench or common pleas, or by justices of assize, every such person shall not only forfeit his right to such office, or to the nomination thereof, but the person giving such reward, &c. shall be disabled to hold such office. But it has been decided that where an office is within the statute, and the salary certain, if the principal makes a deputy, reserving by bond a less sum out of the salary, it is good; or, if the profits are uncertain, reserving a part as half the profits, it is good; for the fees still belong to the principal, in whose name they must be sued for. Salk. 466. But where a person so appointed, gives a bond to the principal to pay him a sum certain, without reference to the profits; this is void under the statute. Salk. 465.

To offer money to any officer of state, to procure the reversion of an office in the gift of the crown, is a misdemeanor at common law, and punishable by information; and even the attempt to induce him under the influence of a bribe, is criminal, though never carried into execution. Any contract to procure the nomination to an office, not within the stat. 6 Ed. VI. is defective on the ground of public policy, and the money agreed to be given is not recoverable.

Office, in the canon-law, is used for a benefice that has no jurisdiction annexed to it. It is also used for divine service celebrated in public; and in the Romish church it is applied to a particular prayer preferred in honour of some saint; thus, when any saint is canonized, a particular office is at the same time assigned him, out of the common office of the confessors, the Virgin, &c. We say the office of the Holy Spirit, of the Virgin, of the passion, of the holy sacrament, of the dead, &c.

OFFICER, a person possessed of a post or office. See the preceding article. The great officers of the crown, or state, are the lord high steward, the lord high chancellor, the lord high treasurer, the lord president of the council, the lord privy seal, the lord chamberlain, the lord high constable, the earl marshal; each of which see under its proper article.

Officers, *commission*, are those appointed by the king's commission; such are all from the general to the cornet inclusive, who are thus denominated in contradistinction to warrant-officers, who are appointed by the colonel's or captain's warrant, as quarter-masters, serjeants, corporals, and even chaplains and surgeons.

Officers, *general*, are those whose command is not limited to a single company, troop, or regiment; but extends to a body of forces, composed of several regiments; such are the general, lieutenant-general, major-generals, and brigadiers.

Officers, *staff*, are such as, in the king's presence, bear a white staff or wand; and at other times, on their going abroad, have it carried before them by a footman bareheaded; such are the lord steward, lord chamberlain, lord treasurer, &c.

The white staff is taken for a commission, and at the king's death each of these officers breaks his staff over

the hearse made for the king's body, and by this means lays down his commission, and discharges all his inferior officers.

OFFICERS, *subaltern*, are all who administer justice in the name of subjects; as those who act under the earl marshal, admiral, &c. In the army, the subaltern officers are the lieutenants, cornets, ensigns, serjeants, and corporals.

OFFICIAL, in the canon law, an ecclesiastical judge, appointed by a bishop, chapter, abbot, &c. with charge of the spiritual jurisdiction of the diocese. Of these there are two kinds; the one is in a manner the vicar-general of the diocese, and is called by the canonists officialis principalis, and in our statute-law, the bishop's chancellor. There is no appeal from his court to the bishop, his being esteemed the bishop's court. The other called officialis foraneus, and is appointed by the bishop when the diocese is very large; he has but a limited jurisdiction, and has a certain extent of territory assigned him, wherein he resides.

OFFING, or OFFIN, in the sea-language, that part of the sea a good distance from shore, where there is deep water, and no need of a pilot to conduct the ship; thus, if a ship from shore is seen sailing out to sea-ward, they say, she stands for the offing; and if a ship, having the shore near her, has another a good way without her, or towards the sea, they say, that ship is in the offing.

OIL, which is of such extensive utility in the arts' was known at a very remote period. It is mentioned in Genesis, and during the time of Abraham was even used in lamps. The olive was very early cultivated, and oil extracted from it in Egypt. Cecrops brought it from Sais, a town in Lower Egypt, where it had been cultivated from time immemorial, and taught the Athenians to extract oil from it. In this manner the use of oil became known in Europe. But the Greeks seem to have been ignorant of the method of procuring light by means of lamps till after the siege of Troy; at least Homer never mentions them, and constantly describes his heroes as lighted by torches of wood. There are two classes of oils exceedingly different from each other; namely, fixed oils and volatile oils.

Fixed oils are distinguished by the following characters:

1. Liquid, or easily becoming so when exposed to a gentle heat. 2. An unctuous feel. 3. Very combustible. 4. A mild taste. 5. Boiling point not under 600°. 6. Insoluble in water and alcohol. 7. Leave a greasy stain upon paper.

Those oils which are called also fat or expressed oils, are numerous; and are obtained, partly from animals and partly from vegetables, by simple expression. As instances may be mentioned, whale-oil or train-oil, obtained from the blubber of the whale; olive-oil, obtained from the fruit of the olive; linseed-oil and almond-oil, obtained from linseed and almond-kernels. Fixed oils may also be extracted from poppy-seeds, hemp-seeds, beech-mast, and many other vegetable substances.

It deserves attention, that the only part of vegetables in which fixed oils are found is the seeds of bicotyledinous plants. In animals they are most usually deposited in the liver, though they are found also in the eggs of fowls.

All these oils differ from each other in several particulars, but they also possess many particulars in common. Whether the oily principle in all the fixed oils is the same, and whether they owe their differences to accidental ingredients, is not yet completely ascertained, as no proper analysis has hitherto been made; but it is not improbable, as all the oils hitherto tried have been found to yield the same products. In the present state of our knowledge, it would be useless to give a particular description of all the fixed oils, as even the differences between them have not been accurately ascertained.

Fixed oils are considered at present as composed of hydrogen and carbon. Lavoisier analysed olive-oil by burning a given portion of it in oxygen gas, by means of a particular apparatus. During the combustion there was consumed

Of oil - -	15.79 grain troy
Of oxygen gas	50.86
Total	66.65

The products were carbonic acid and water. The carbonic acid obtained amounted to 44.50 grains; the weight of the water could not be accurately ascertained; but as the whole of the substances consumed were converted into carbonic acid gas and water, it is evident, that if the weight of the carbonic acid is subtracted from the weight of these substances, there must remain precisely the weight of the water. Mr. Lavoisier accordingly concluded, by calculation, that the weight of the water was 22.15 grains. Now the quantity of oxygen in 44.50 grains of carbonic acid gas is 32.04 grains, and the oxygen in 22.15 grains of water is 18.82 grains; both of which taken together amount to 50.86 grains, precisely the weight of the oxygen gas employed.

The quantity of charcoal in 44.50 grains of carbonic acid gas is 12.47 grains; and the quantity of hydrogen in 22.15 grains of water is 3.32 grains; both of which, when taken together, amount to 15.79 grains, which is the weight of the oil consumed.

It follows, therefore, from this analysis, that 15.79 grains of olive oil are composed of

12.47 carbon
3.32 hydrogen.

Olive-oil therefore is composed of about

79 carbon
21 hydrogen

100.

This however can only be considered as a very imperfect approximation towards the truth.

Fixed oil is usually a liquid with a certain degree of viscidity, adhering to the sides of the glass vessels in which it is contained, and forming streaks. It is never perfectly transparent, having always a certain degree of colour; most usually it is yellowish or greenish. Its taste is sweet, or nearly insipid. When fresh, it has little or no smell. Its specific gravity varies from 0.9403 (the specific gravity of linseed-oil) to 0.9153 (the specific gravity of olive-oil).

Fixed oil is insoluble in water. When the two liquids are agitated together, the water loses its transparency,

and acquires the white colour and consistency of milk. This mixture is known by the name of emulsion. When allowed to remain at rest, the oil soon separates, and swims upon the surface of the water.

Fixed oil does not evaporate till it is heated to about 600°. At that temperature it boils, and may be distilled over; but it is always somewhat altered by the process. Some water and sebacic acid seem to be formed, a little charcoal remains in the retort, and the oil obtained is lighter, more fluid, and has a stronger taste, than before. Oil thus distilled was formerly distinguished by the name of philosophical oil.

Fixed oil, when in the state of vapour, takes fire on the approach of an ignited body, and burns with a yellowish-white flame. It is upon this principle that candles and lamps burn. The tallow or oil is first converted into the state of vapour in the wick; it then takes fire, and supplies a sufficient quantity of heat to convert more oil into vapour; and this process goes on while any oil remains.

The wick is necessary to present a sufficiently small quantity of oil at once for the heat to act upon. If the heat was sufficiently great to keep the whole oil at the temperature of 600°, no wick would be necessary, as is obvious from oil catching fire spontaneously when it has been raised to that temperature.

When exposed to the action of cold, fixed oils lose their fluidity, and are converted into ice; but this change varies exceedingly in different oils.

When fixed oils are exposed to the open air or to oxygen gas, they undergo different changes according to the nature of the oil:

1. Some of them dry altogether, without losing their transparency, when thin layers of them are exposed to the atmosphere. These are distinguished by the name of drying oils, and are employed by painters. Linseed-oil, nut-oil, poppy-oil, and hempseed-oil, possess this property; but linseed-oil is almost the only one of these liquids employed in this country as a drying-oil. The cause of this peculiarity has not been completely investigated; but it is well known that these oils possess the drying quality at first but imperfectly. Before they can be employed by painters, they must be boiled with a little litharge. During this operation the litharge is partly reduced to the metallic state. Hence it has been conjectured that drying oils owe their peculiar properties to the action of oxygen; which is supposed either to constitute one of their component parts, or to convert them into drying oils by diminishing their hydrogen.

2. Other fixed oils, when exposed to the atmosphere, gradually become thick, opaque, and white, and assume an appearance very much resembling wax or tallow. These have been distinguished by the term fat oils. Olive-oil, oil of sweet almonds, or rape-seed, and of ben, belong to this class.

When oil is poured upon water, so as to form a thin layer on its surface, and is in that manner exposed to the atmosphere; these changes are produced much sooner. Berthollet, who first examined these phenomena with attention, ascribed them to the action of light: but Sennebier observed that no such change was produced on the oil though ever so long exposed to the light, provided atmospherical air was excluded; but that it took place on the admission of oxygen gas, whether the oil was exposed to the light or not. It cannot be doubted, then, that it is owing to the action of oxygen. It is supposed at present to be the consequence of the simple absorption of oxygen and its combination with the oils.

3. Both these classes of oils, when exposed in considerable quantity to the action of the atmosphere, undergo another change, well known under the name of rancidity. But the fat oils become rancid much more readily than the drying oils. Rancid oils are thick, have usually a brown colour, convert vegetable blues to red, and have the smell and taste of sebacic acid. During the change which they undergo, some drops of water also appear on their surface. The rancidity of oils then is owing to the formation of a quantity of acid in them. This, together with the water, is evidently the consequence of a partial decomposition.

Fixed oils readily dissolve sulphur when assisted by heat. The solution assumes a reddish colour. When distilled, there comes over a great quantity of sulphureted hydrogen gas. When the solution is allowed to cool, the sulphur is deposited in chrystals. By this process Pelletier obtained sulphur in regular octahedrons.

They likewise dissolve a small proportion of phosphorus when assisted by heat. These oily phosphurets emit the colour of phosphureted hydrogen, and yield, when distilled, a portion of that gas. When rubbed in the open air, or when spread upon the surface of other bodies, they appear luminous in consequence of the combustion of the phosphorus. When hot oils saturated with phosphorus are allowed to cool, the phosphorus chrystallizes in octahedrons, as Pelletier ascertained.

Charcoal has no sensible action on fixed oils; but when they are filtered through charcoal-powder, they are rendered purer, the charcoal retaining their impurities. Neither hydrogen nor azotic gas has any action on fixed oils.

Fixed oils have scarcely any action upon metals; but they combine with several metallic oxides, and form compounds known by the name of plasters. See Plaster.

They combine likewise with alkalies and earths, and form with them compounds called soaps. The fat oils enter into these combinations much more readily than the drying oils. See Soap.

Fixed oils absorb nitrous gas in considerable quantities, and at the same time become much thicker and specifically heavier than before.

Sulphuric acid decomposes fixed oils, at least when concentrated. It renders them first thick and of a brown colour; then water is formed, charcoal precipitated, and an acid formed. Nitric acid renders them thick and viscid. When nitrous acid is poured upon the drying oils, it inflames them without addition; but it does not produce that effect upon the fat oils, unless it is mixed with a portion of sulphuric acid.

The affinities of fixed oils are as follows:

Lime	Ammonia,
Barytes	Oxide of mercury,
Fixed alkalies,	Other metallic oxides,
Magnesia,	Alumina.

The importance of fixed oils is well known. Some of them are employed as seasoners of food; some are burnt in lamps; some form the basis of soap; not to mention

their utility in painting, and the many other important purposes which they serve.

OILS, *volatile*, called also essential oils, are distinguished by the following properties:

1. Liquid; often almost as liquid as water; sometimes viscid.
2. Very combustible.
3. An acrid taste and a strong fragrant odour.
4. Boiling point not higher than 212°.
4. Soluble in alcohol; and imperfectly in water.
6. Evaporate without leaving any stain on paper.

By this last test it is easy to discover whether they have been adulterated with any of the fixed oils. Let a drop of the volatile oil fall upon a sheet of writing-paper, and then apply a gentle heat to it. If it evaporates without leaving any stain upon the paper, the oil is pure; but if it leaves a stain, it has been contaminated with some fixed oil or other.

Volatile oils are almost all obtained from vegetables, and they exist in every part of plants; the root, the bark, the wood, the leaves, the flower, and even the fruit: though they are never found in the substance of the cotyledons; whereas the fixed oils, on the contrary, are almost always contained in these bodies.

When the volatile oils are contained in great abundance in plants, they are sometimes obtained by simple expression. This is the case with the oil of oranges, of lemons, and of bergamot; but in general they can only be obtained by distillation. The part of the plant containing the oil is put into a still with a quantity of water, which is distilled off by the application of a moderate heat. The oil comes over along with the water, and swims upon its surface in the receiver. By this process are obtained the oils of peppermint, thyme, lavender, and a great many others, which are prepared and employed by the perfumer. Others are procured by the distillation of resinous bodies. This is the case in particular with oil of turpentine, which is obtained by distilling a kind of resinous juice, called turpentine, that exudes from the juniper.

The greater number of volatile oils are liquid, and some of them are as transparent and colourless as water. This is the case with the oil of turpentine; but for the most part they are coloured. Some of them are yellow, as the oil of lavender; some brown, as the oil of rhodium; some blue, as the oil of camomile: but the greater number of volatile oils are yellow or reddish-brown.

Their odours are so various as to defy all description. It is sufficient to say, that all the fragrance of the vegetable kingdom resides in the volatile oils. Their taste is always acrid, hot, and exceedingly unpleasant. Their specific gravity is for the most part less than that of water; but some volatile oils, as those of canella and sassafras, are heavier than water. The specific gravity of the volatile oils varies from 0.8697 to 1.0439.

Water dissolves a small portion of volatile oils, and acquires the odour and the taste of the oil which it holds in solution.

When heated they evaporate very readily and without alteration. They are much more combustible than fixed oils, owing to their greater volatility. They burn with a fine bright white flame, exhale a great deal of smoke, deposit much soot, and consume a greater portion of the oxygen of the atmosphere than fixed oils. The products of their combustion are water and carbonic acid gas. From these facts it has been concluded that they are composed of the same ingredients as the fixed oils, but that they contain a greater portion of hydrogen.

When exposed to the action of cold they congeal like the fixed oils; but the temperature necessary to produce this effect, varies according to the oil. Some of them, as oil of anise and of fennel, become solid at the temperature of 50°; frozen oil of bergamot and of canella become liquid at 23°; oil of turpentine at 14°. Margueron exposed several volatile oils to a cold of 17°. They congealed or rather chrystallized partially, and at the same time emitted an elastic fluid. These chrystals consisted partly of the oils themselves, partly of other substances. Some of them had the properties of benzoic acid.

Volatile oils, when exposed to the action of light in close vessels, and excluded from common air, undergo very singular changes. Their colour becomes deeper, they acquire a great deal of consistency, and their specific gravity is considerably increased. The cause of these changes is but imperfectly known. Tingry, to whom we are indebted for these interesting researches, has proved that light is a necessary agent. It was supposed formerly that they were occasioned by the absorption of oxygen; and when oxygen is present, it has been ascertained that it is absorbed; but Tingry has proved that the same changes go on when oxygen is excluded. This philosopher ascribes them to the fixation of light. If this is the real cause, the quantity of light fixed must be enormous; for as the specific gravity of the oils is increased considerably while the bulk continues the same, it is evident that the absolute weight must be increased proportionably. One circumstance, however, renders this conclusion somewhat doubtful, at least in its full extent; and that is, that the quantity of change was always proportional to the quantity of the oil and the quantity of air contained in the vessel.

When exposed to the open air their colour becomes gradually deeper, and they acquire consistency, while they exhale at the same time a very strong odour. The air around, as Priestly first ascertained, is deprived of its oxygen, a quantity of water is formed, and the oils at last, for the most part, assume the form of resins.

Volatile oils dissolve sulphur and phosphorus, and the solutions have nearly the same properties as those made by means of fixed oils.

They have no action on the metals, and seem scarcely capable of combining with the metallic oxides.

They combine only imperfectly, and in small quantities, with alkalies and earths. The French chemists have proposed to give these combinations the name of savonnules, which Dr. Pearson has translated by the term saponules; but these denominations have not been adopted by chemists.

They absorb nitrous gas in great abundance, and with great difficulty, and seemingly decompose it, acquiring a thick consistence and a resinous appearance, as if they had absorbed oxygen.

Sulphuric acid decomposes volatile oils; carbureted

hydrogen gas is emitted, and charcoal is precipitated. Nitric acid inflames them, and converts them into water, carbonic acid, and charcoal. Oxymuriatic acid converts them into substances analogous to resins.

Volatile oils are applied to a great number of uses. Some of them are employed in medicine; some of them, as oil of turpentine, are much used to dissolve resins, which are afterwards employed as varnishes; not to mention their employment in painting and in perfumery.

Besides the oils which exist ready formed in the vegetable and animal kingdoms, there are a variety of others which are obtained when animal or vegetable bodies are distilled by means of a heat above that of boiling water. These oils have received the appellation of empyreumatic, because they are formed by the action of the fire.

The following is a list of the plants which yield the fixed oils occurring usually in commerce:

1. Linum usitatissimum et perenne -	Linseed oil
2. Corylus avellana 3. Juglans regia	Nut oil
4. Papaver somniferum	Poppy oil
5. Cannabis sativa -	Hemp oil
6. Sesamum orientale	Oil of sesamum
7. Olea Europea - -	Olive oil
8. Amygdalus communis	Almond oil
9. Guilandina Mohringa	Oil of behen
10. Cacurbita pepo & melapepo	Cucumber oil
11. Fagus sylvatica -	Beech oil
12. Sinapis nigra et arvensis	Oil of mustard
13. Helianthus annuus et perennis	Oil of sunflower
14. Brassica napus & campestris	Rapeseed oil
15. Ricinus communis -	Castor oil
16. Nicotiana tabacum et rustica -	Tobacco-seed oil
17. Prunus domestica -	Plum-kernel oil
18. Vitis vinifera - -	Grapeseed oil
19. Theobroma cacao -	Butter of cacao
20. Laurus nobilis - -	Laurel oil
21. Arachis hypogæa -	Ground nut oil.

The following Table contains a copious list of plants which yield volatile oils. The part of the plant from which it is extracted, and the English name of the oil, are added in separate columns.

Plants.	Parts.	Oil of	Colour.
1. Artemisia absyathium	Leaves -	Wormwood -	Green
2. Acorus calamus -	Root -	Sweet flag -	Yellow
3. Myrtus pimenta -	Fruit -	Jamaica pepper	Yellow
4. Anethum graveolens	Seeds -	Dill -	Yellow
5. Angelica archangelica	Root -	Angelica	
6. Pimpinella anisum	Seeds -	Anise -	White
7. Illicium anisatum -	Seeds -	Stellat. anise -	Brown
8. Artemisia vulgaris	Leaves -	Mugwort	
9. Citrus aurantium	Rind of the fruit	Bergamot -	Yellow
10. Meloleuca leucodendra	Leaves -	Cajeput - -	Green
11. Eugenia caryophyllata	Capsules -	Cloves -	Yellow
12. Carum carui -	Seeds -	Caraways -	Yellow
13. Amomum cardamomum	Seeds -	Card. seeds -	Yellow
14. Carlina acaulis -	Roots -	- -	White
15. Scandix chaerefolium	Leaves -	Chervil -	Sulph. yellow
16. Matricaria chamomilla	Petals -	Chamomile -	Blue
17. Laurus cinnamomum	Bark -	Cinnamon -	Yellow
18. Citrus medica -	Rind of the fruit	Lemons -	Yellow
19. Cochlearia officinalis	Leaves -	Scurvy grass -	Yellow
20. Copaifera officinalis	Extract -	Copaiba -	White
21. Coriandrum sativum	Seeds -	Coriand. seed	White
22. Crocus sativus -	Pistils -	Saffron -	Yellow
23. Piper cubeba -	Seeds -	Cubeb pepper	Yellow
24. Laurus culilaban	Bark -	Culilaban -	Brown yellow
25. Cuminum cymium	Seeds -	Cummi -	Yellow
26. Inula helenium -	Roots -	Elecampane -	White
27. Anethum fœniculum	Seeds -	Fennel -	White
28. Croton eleutheria	Bark -	Cascarilla -	Yellow
29. Maranta galanga	Roots -	Galanga -	Yellow
30. Hyssopus officinalis	Leaves -	Hyssop - -	Yellow
31. Juniperus communis	Seeds -	Juniper -	Green
32. Lavendula spica	Flowers -	Lavender -	Yellow
33. Laurus nobilis -	Berries -	Laurel -	Brownish
34. Prunus laurocerasus	Leaves -	Laurocerasus	
35. Levisticum logusticum	Roots -	Lovage -	Yellow
36. Myristica moschata	Seeds -	Mace -	Yellow
37. Origanum majorana	Leaves -	Marjoram -	Yellow

38. Pistacia lentiscus	Resin -	Mastich -	Yellow
39. Matricaria parthenium	Plant -	Motherwort -	Blue
40. Melissa officinalis -	Leaves -	Balm -	White
41. Mentha crispa -	Leaves -	- -	White
42. ——— piperitis -	Leaves -	Peppermint -	Yellow
43. Achillea millefolium	Flowers -	Millefoil -	Blue and green
44. Citrus aurantium -	Leaves -	Neroli -	Orange
45. Origanum creticum -	Flowers -	Spanish hop -	Brown
46. Apium petroselinum -	Roots -	Parsley -	Yellow
47. Pinus sylvestris et abies	Wood and resin	Turpentine -	Colourless
48. Piper nigrum -	Seeds -	Pepper -	Yellow
49. Rosmarinus officinalis	Plant -	Rosemary -	Colourless
50. Mentha pulegium -	Flowers -	Pennyroyal -	Yellow
51. Genista canariensis -	Root -	Rhodium -	Yellow
52. Rosa centifolia -	Petals -	Roses -	Colourless
53. Ruta graveolens -	Leaves -	Rue -	Yellow
54. Juniperus sabina -	Leaves -	Savine -	Yellow
55. Salvia officinalis -	Leaves -	Sage -	Green
56. Santalum album -	Wood -	Santalum -	Yellow
57. Laurus sassafras -	Root -	Sassafras -	Yellow
58. Satureia hortensis -	Leaves -	Satureia -	Yellow
59. Thymus serpillum -	Leaves & flowers	Thyme -	Yellow
60. Valeriana officinalis -	Root -	Valerian -	Green
61. Kæmpferia rotunda -	Root -	Zedoary -	Greenish blue
62. Amomum Zinziber -	Root -	Ginger -	Yellow
63. Andropogon schænanthum		Sira -	Brown.

Several of the gum-resins, as myrrh and galbanum, yield an essential oil; and likewise the balsams, as benzoin, &c.

Oil-Mill. See Olea.

OLAX, a genus of the triandria monogynia class and order. The calyx is entire, trifid; corolla funnel-form, trifid; nect. four; berry three-celled, many-seeded. There is one species, a tree of Ceylon.

OLDENLANDIA, a genus of the tetrandria monogynia class and order. Its character are these: the empalement of the flower is permanent, sitting upon the germen; the flower has four oval petals, which spread open, and four stamina, terminated by small summits; it has a roundish germen, situated under the flower, crowned by an indented stigma: the germen afterwards turns to a globular capsule, with two cells filled with small seeds. There are sixteen species, herbs of the Cape, &c.

OLD-WIFE, or Wrasse. See Labrus.

OLEA, the *olive-tree*, a genus of the monogynia order, in the diandria class of plants; and in the natural method ranking under the 44th order, sapieriæ. The corolla is quadrifid; with the segments nearly ovate. The fruit is a monospermous plum. There are seven species; the most remarkable are:

1. The Europea, or common olive-tree, rises with upright solid stems, branching numerously on every side, 20 or 30 feet high; spear-shaped, stiff, opposite leaves, two or three inches long, and half an inch or more broad; and at the axillas small clusters of white flowers, succeeded by oval fruit. This species is the principal sort cultivated for its fruit; the varieties of which are numerous, varying in size, colour, and quality. It is a native of the southern parts of Europe, and is cultivated in great quantities in the south of France, Italy, and Portugal, for the fruit to make the olive-oil.

2. The capensis, or Cape box-leaved olive. 3. Olea odoratissima, the flower of which is by some said to give the fine flavour to the green tea; but Thunberg attributes the flavour to the cemellic seserque.

Olive-trees are easily propagated by shoots, which, when care has been taken to ingraft them properly, bear fruit in the space of eight or ten years. Those kinds of olive-trees which produce the purest oil, and bear the greatest quantity of fruit, are ingrafted on the stocks of inferior kinds. Different names are assigned by the French to the different varieties of the olive-tree; and of these they reckon 19, whilst in Florence are cultivated no fewer than 32. Olive-shoots are ingrafted when in flower; if the operation has been delayed, and the tree bears fruit, it is thought sufficient to take off a ring of bark, two fingers' breadth in extent, above the highest graff. In that case the branches do not decay the first year; they afford nourishment to the fruit, and are not lopped off till the following spring. Olive-trees are commonly planted in the form of a quincunx, and in rows at a considerable distance from one another. Between the rows it is usual to plant vines, or to sow some kind of grain. It is observed, that olives, like many other fruit-trees, bear well only once in two years. The whole art of dressing these trees consists in removing the superfluous wood; for it is remarked, that trees loaded with too much wood produce neither so much fruit nor of so good a quality. Their propagation in England is commonly by layers.

Olives have an acrid, bitter, and extremely disagreeable taste; pickled (as we receive them from abroad) they prove less disagreeable. The Lucca olives, which are smaller than the others, have the weakest taste; the Spanish, or larger, the strongest; the Provence, which are of a middling size, are generally the most esteemed.

When olives are intended for preservation, they are gathered before they are ripe. The art of preparing them consists in removing their bitterness, in preserving them green, and in impregnating them with a brine of aromatised sea-salt, which gives them an agreeable taste. For this purpose, different methods are employed: formerly they used a mixture of a pound of quicklime, with six pounds of newly sifted woodashes; but of late, instead of the ashes, they employ nothing but a ley. This, it is alleged, softens the olives, makes them more agreeable to the taste, and less hurtful to the constitution. In some parts of Provence, after the olives have lain some time in the brine, they remove them, take out the kernel, and put a caper in its place. These olives they preserve in excellent oil; and when thus prepared, they strongly stimulate the appetite in winter. Olives perfectly ripe are soft, and of a dark red colour. They are then eaten without any preparation, excepting only a seasoning of pepper, salt, and oil; for they are extremely tart, bitter, and corrosive.

The oil is undoubtedly that part of the produce of olive-trees which is of greatest value. The quality of it depends on the nature of the soil where the trees grow, on the kind of olive from which it is expressed, on the care which is taken in the gathering and pressing of the fruit, and likewise on the separation of the part to be extracted. Unripe olives give an intollerable bitterness to the oil; when they are over-ripe, the oil has an unguinous taste; it is therefore of importance to choose the true point of maturity. When the situation is favourable, those species of olives are cultivated which yield fine oils; otherwise they cultivate such species of trees as bear a great quantity of fruit, and they extract oil from it, for the use of soaperies, and for lamps.

They gather the olives about the months of November or December. It is best to put them as soon as possible into baskets, or into bags made of wool or hair, and to press them immediately, in order to extract a fine oil. Those who make oil only for soaperies, let them remain in heaps for some time in their storehouses; when afterwards pressed, they yield a much greater quantity of oil. In order to obtain the oil, the olives are first bruised in a round trough, under a mill-stone, rolling perpendicularly over them; and when sufficiently mashed, put into the maye, or trough, *m*, of an olive-press (Plate XCIV. Miscel. fig. 177), where *aa* are the upright beams, or cheeks; *b* the female, and *c* the male screw; *e*, the bar for turning the screw: *f*, the board on which the screw presses; *g*, a cubical piece of wood, called a block; *h*, the peel, a circular board to be put under the block. By turning the screw, all the liquor is pressed out of the mashed olives, and is called virgin-oil; after which, hot water being poured upon the remainder in the press, a coarser oil is obtained. Olive-oil keeps only about a year, after which it degenerates.

Oil of olives is an ingredient in the composition of a great many balsams, ointments, plasters, mollifying and relaxing liniments. It is of an emollient and solvent nature; mitigates gripes of the cholic, and the pains accompanying dysentery; and is supposed a good remedy when any person has chanced to swallow corrosive poisons. It is an effectual cure for the bite of a viper; and, as M. Bourgeois tells us, for the sting of wasps, bees, and other insects. A bandage soaked in the oil is immediately applied to the sting, and a cure is obtained without any inflammation or swelling. Olive-oil is of no use in painting, because it never dries completely. The best soap is made of it, mixed with Allicant salt-wort and quick-lime.

OLERON, *see laws of*, certain laws relating to maratime affairs, made in the time of Richard I. when he was at the island of Oleron.

These laws, being accounted the most excellent sea-laws in the world, are recorded in the black book of the admiralty.

OLIBANUM, a dry resinous substance obtained from the juniperus lycia, and chifly collected in Arabia. It is the frankincense of the ancients. It is in transparent brittle masses about the size of a chesnut. Its colour is yellow. It has little taste, and when burnt diffuses an agreeable odour. Alcohol dissolves it; and with water it forms a milky liquid. When distilled, it yields a small quantity of volatile oil. Specific gravity, 1.73.

OLIVE. See Olea.

OLYMPIC Games, were solemn games, famous among the ancient Greeks, so called from Olympian Jupiter, to whom they were dedicated.

OLYRA, a genus of the triandria order, in the monœcia class of plants, and in the natural method ranking under the 4th order, gramina. The male calyx is a biflorous and aristated glume; the corrolla a beardless glume; the female calyx is an uniflorous, patulous, and ovate glume; the style is bifid, and the seed cartilaginous. There are two species, herbs of Jamaica.

OMBRE, a game at cards, played by 2, 3, or 5 persons; in all other respects resembling quadrille.

OMENTUM. See Anatomy.

OMNIUM, a term in use among stock-jobbers to express all the articles included in the contract between government and the original subscribers to a loan, which of late years has generally consisted of different proportions of 3 and 4 per cent. stock, with a certain quantity of terminable annuities. Those who dispose of their share soon after the agreement is concluded, generally get a premium of 2 or 3 per cent. for it, which fluctuates with the current prices of the public funds; and in a few instances the omnium has been at a considerable discount. Some of the subscribers pay their whole subscription at the time fixed for the first or second payment, and their shares become immediately transferable stock: others dispose of the several articles which make up the terms of the loan, separately; and in this state the 3 or 4 per cent. consols, &c. are distinguished by the name of scrip, till the whole sum has been paid in upon them.

OMPHALEA, a genus of the triandria order, in the monœcia class of plants, and in the natural method ranking with those of which the order is doubtful. The male calyx is tetraphyllous; there is no corolla; the receptacle, into which the antheræ are sunk, is ovate. The female calyx and corolla are as in the male; the stigma trifid; the capsule carnous and trilocular, with one seed. There are four species, shrubs of Jamaica.

ONCHIDIUM, a genus of insects of the order vermes mollusca: the generic character is; body oblong, creeping, flat beneath, mouth placed before; feelers two, situated above the mouth; arms two, at the sides of the head; vent behind, and placed beneath. The onchidium

typhæ, the only species, inhabits Bengal, on the leaves of the typha elephantina, about an inch long, and three quarters of an inch broad, but linear and longer when creeping. In appearance it very much resembles a limax, but differs principally in wanting the shield and lateral pore, and in being furnished with a vent behind. Body above convex, beneath flat and smooth; head small, and placed beneath, which, when the animal is in motion, is perpetually changing its form and size, and drawn in when at rest; mouth placed lengthways, and continually varying its shape from circular to linear; feelers retractile, resembling those of a slug, and apparently tipt with eyes; arms dilatable, solid, compressed, and somewhat palmate when fully expanded.

ONION. See ALLIUM.

ONISCUS, a genus of insects of the order aptera: the generic character is; legs fourteen; antennæ setaceous; body oval. Of this genus, which consists of more than 40 species, the best known is the oniscus asellus, popularly known by the name of the woodlouse. It is a very common insect in gardens, fields, &c. and is observed in great quantities under the barks of decayed trees, beneath stones in damp situations, &c. Its general length is about half an inch, or rather more, and its colour livid brown, the larger specimens often exhibiting a double series of pale spots down the back: like the rest of the genus, it preys on the minuter insects.

2. Oniscus armadillo, or the medical woodlouse, is of somewhat larger size than the preceding, much darker colour, and of a polished surface: it is equally common with the preceding species, and is found in similar situations; when suddenly disturbed or handled, it rolls itself up into a completely globular form, in the manner of the curious quadrupeds called armadillos, frequently remaining in this state for a very considerable length of time, or so long as it is any ways disturbed. Swammerdam relates a ludicrous mistake of a servant-maid, who, finding in the garden a great many in this globular state, imagined she had discovered some handsome materials for a necklace, and betook herself to stringing them with great care; but on suddenly perceiving them unfold, was seized with a panic, and ran shrieking into the house.

Though considered as of but slight importance in the present practice of physic, these animals once maintained a very respectable station in the materia medica, under the title of millipedes.

3. Oniscus aquaticus is a native of the clearer kind of stagnant waters, and is of the general size and colour of the oniscus asellus, but of a more lengthened form, and with longer limbs in proportion; the two last legs being bifid. This species is viviparous, and of a considerably prolific nature.

Among the marine insects of this genus the largest is the oniscus entomon, measuring two inches in length: its general form and colour resemble that of the oniscus ascellus, but the four lower pair of legs are longer in proportion, the three first pair being very small and short; the tail is long and pointed. It is a native of the European seas, and is found about rocks, &c. It is of a strong fabric, the divisions of the upper part being of an almost calcareous nature. This animal is capable of living several days in fresh water.

ONOCLEA, a genus of the class and order cryptogamia filices. The capsules are under the recurved and contracted pinnules of the frond, resembling pericarps. There are two species.

ONONIS, or ANONIS, *rest-harrow*, in botany. See ANONIS.

ONOPORDUM, a genus of the class and order syngenesia polygamia æqualis. The essential character is, calyx scales mucronate; recept. honey-combed. There are seven species, one of them well known under the name of cotton-thistle or pig-leaves.

ONOSMA, a genus of the monogynia order, in the pentandria class of plants, and in the natural method ranking under the 41st order, asperifoliæ. The corolla is campanulated, with the throat pervious: there are four seeds. There are three species, rock plants of the South of Europe.

ONYX, in natural history, one of the semipellucid gems, with variously-coloured zones, but none red; being composed of crystal, debased by a small admixture of earth, and made up either of a number of flat plates, or of a series of coats surrounding a central nucleus, and separated from each other by veins of a different colour, resembling zones or belts. We have four species of this gem: 1. A blueish-whit eone, with broad white zones. 2. A very pure onyx, with snow-white veins. 3. The jasponyx, or horny onyx, with green zones. 4. The brown onyx, with blueish-white zones. The ancients attributed wonderful properties to the onyx, and imagined that if worn on the finger it acted as a cardiac; they have also recommended it as an astringent, but at present no regard is paid to it. The word in the Greek language signifies nail; the poets feigning this stone to have been formed by the Parcæ from a piece of Venus's nails, cut off by Cupid with one of his arrows. See CHALCEDONY.

OOLITE. See PISOLITE.

OPACITY, in philosophy, a quality of bodies which renders them impervious to the rays of light.

The cause of opacity in bodies does not consist, as was formerly supposed, in the want of rectilinear pores, pervious every way; but either in the unequal density of the parts, in the magnitude of the pores, or in their being filled with a matter, by means of which the rays of light in their passage are arrested by innumerable refractions and reflections, become extinct, and are absorbed.

OPAL, in mineralogy; this stone is found in many parts of Europe, especially in Hungary, in the Crapacks near the village of Czennizka. When first dug out of the earth it is soft, but it hardens and diminishes in bulk by exposure to the air. The substance in which it is found is a ferruginous sand-stone.

The opal is always amorphous. Its fracture is conchoidal. Commonly somewhat transparent. Specific gravity from 1.958 to 2.540. The lowness of its specific gravity, in some cases, is to be ascribed to accidental cavities which the stone contains. These are sometimes filled with drops of water. Some specimens of opal have the property of emitting various-coloured rays, with a particular effulgency, when placid between the eye and the light. The opals which possess this property are distinguished by lapidaries by the epithet Oriental; and often by mineralogists by the epithet nobilis. This property rendered the stone much esteemed by the ancients. Opals acquire it by exposure to the sun. Werner has

divided this species into five subspecies:

1. Noble opal. Lustre internal, glassy. Colour, usually light blueish-white. When its position is varied, it reflects the light of various bright colours. Brittle. Specific gravity 2.114. Does not melt before the blow-pipe. When heated it becomes opaque, and sometimes is decomposed by the action of the atmosphere. Hence it seems to follow that water enters essentially into its composition. A specimen of this variety, analysed by Klaproth, contained

90	silica,
10	water
100.	

2. Common opal. Fracture imperfectly conchoidal. Lustre external and internal, glassy or greasy. Its colours are very various; milk-white, yellows, reds, greens of different kinds. Infusible by the blowpipe.

Specimens of this variety sometimes occur with rifts: these readily imbibe water, and therefore adhere to the tongue. Some opals gradually become opaque, but recover their transparency when soaked in water by imbibing that fluid. They are then called hydrophanes, or oculi mundi. The constituents of the common opal, as ascertained by Klaproth, are

Opal of Kosemutz.		Opal of Telkobanya.
98.75	-	93.5 silica
0.1	-	1.0 oxide of iron
0.1	-	0.0 alumina
0.0	-	5.0 water.
98.95		99.5

3. Semi-opal. Colours, various shades of white, grey, yellow, red, brown, often mixed together. Lustre glassy, sometimes greasy. Fracture imperfectly conchoidal. Brittle. Sometimes adheres to the tongue. Specific gravity 2.540. Infusible before the blowpipe. Its constituents, as ascertained by Klaproth, are,

Semiopal of Telkobanya		Of Menal-montant.
43.5	-	85.5 silica
47.0	-	0.5 oxide of iron
7.5	-	11.0 water
		1.0 alumina
98.0		0.5 lime.
		98.5

4. Hotz-opal or wood-opal. Colours, various shades of white, grey, brown, yellow, red. Found in large pieces, which have the form of wood. Lustre glassy, sometimes greasy. Fracture in one direction conchoidal, in another exhibiting the texture of wood. Usually opaque. Brittle. Considered as fragments of wood impregnated with semiopal.

5. Under the opal may be placed also the mineral known by the name of cat's-eye. It comes from Ceylon, and is seldom seen by Europeon nineralogists till it has been polished by the lapidary. Mr. Klaproth has described a specimen which he received in its natural state from Mr. Greville of London. Its figure was nearly square, with sharp edges, a rough surface, and a good deal of brilliancy. Its texture is imperfectly foliated. Lustre greasy. Specific gravity 2.625 to 2.66. Colour grey, with a tinge of green, yellow, or white; or brown, with a tinge of yellow or red. In certain positions it reflects a splendid white, as does the eye of a cat: hence the name of this stone.

Two specimens analysed by Klaproth, the first from Ceylon, the other from Malabar, were composed of

95.00	94.50 silicia
1.75	2.00 alumina
1.50	1.50 lime
0.25	0.25 oxide of iron.
98.5	98.25

OPATRUM, a genus of insects of the coleopatra order; the generic character is: antennæ moniliform, thicker towards the top; head projecting from a cavity in the thorax; thorax a little flattened, margined; shells immarginate, longer than the abdomen. There are about 28 species of this genus.

OPERATION. See SURGERY.

OPERATIONS in chemistry. See CHEMISTRY.

OPERCULARIA, a genus of the class and order tetrandria monogynia: the flower is compound; calyx common, one-leafed. There are three species, insignificant herbs of New Holland, &c.

OPHICEPHALUS, a genus of fishes of the order thoracici; the generic character is: head coated with dissimilar scales; body elongated.

1. Ophicephalus punctatus: length about ten inches; dorsal fin commencing at no great distance from the head, and continued nearly to the tail; it is of moderate breadth, and of a dusky colour spotted with black; anal fin of similar shape and colour. Native of India, inhabiting rivers and lakes, and considered as a delicate and wholesome food.

2. Ophicephalus striatus; length about 12 inches; shape rather longer than that of the preceding species. Native of India, inhabiting lakes, where it often grows to a much larger size than first mentioned. It is in equal esteem as a food with the former species, and even recommended as a proper diet for convalescents. Native name wrahl. There is one other species.

OPHIDIUM, a genus of fishes of the order apodes; the generic character is: head somewhat naked; teeth in the jaws, palate, and throat; branchiostegous membrane seven-rayed, patulous; body ensiform.

1. Ophidium barbatum: the head of this fish is small; the upper jaw rather longer than the lower, and both beset with a great many small teeth; the lips are strong and fleshy; in the throat are several small teeth; between the eyes and mouth are four small pores. It is commonly found of the length of eight or nine inches, and sometimes twelve or fourteen; and is met with in all parts of the Mediterranean sea, and in great plenty in the Adriatic. It is often taken by nets in Provence and Languedoc with other kinds of fish, and is most common during the summer season. It is not considered as an elegant fish for the table, the flesh being rather coarse. It feeds on small fishes, crabs, &c. &c.

The ophidium aculeatum, or prickly ophidium, inhabits the fresh rivers in India, feeds on worms and a fat kind of earth, is esculent and long. See Plate C. Nat. Hist. fig. 300. There are four species.

OPHIOGLOSSUM, *adder's tongue*, a genus of the natural order of filices, in the cryptogamia class of plants.

The spike is articulated, flat, and turned to the two sides, with the articuli or joints opening across. There are nine species, of which the only remarkable one is the vulgatum, or common adder's-tongue, which is a native of several places of Britain, growing in meadows and moist pastures. The country-people make an ointment of the fresh leaves, and use it as a vulnerary to green wounds.

OPHIORHIZA, a genus of the monogynia order, in the pentandria class of plants, and in the natural method ranking under the 47th order, stellatæ. The corolla is funnel-shaped; the capsule twin, bilocular, and polyspermous. There are three species, the most remarkable of which is the Asiaticum, or true lignum colubrinum. The root of this is known in the East Indies to be a specific against the poison of that most dreadful animal called the hooded serpent.

The true root is called mungus, for the following reason: There is a kind of weasel in the East Indies, called mungutia by the natives, mungo by the Portuguese, and muncas by the Dutch. This animal pursues the hooded serpent, as the cat does the mouse with us. As soon as the serpent appears, the weasel attacks him; and if she chances to be bitten by him, she immediately runs to find a certain vegetable, upon eating which she returns, and renews the fight. That celebrated traveller Kæmpfer, who kept one of these weasels tame, that ate with him, lived with him, and was his companion wherever he went, says he saw one of these battles between her and the serpent, but could not certainly find out what root the weasel looked out for. But whether the weasel first discovered this antidote or not, it is an infallible remedy against the bite of the hooded serpent. And this he undertakes to ascertain.

OPHIOXYLUM, a genus of the monœcia order, in the polygamia class of plants, and in the natural method ranking with those of which the order is doubtful. The hermaphrodite calyx is quinquefid; the corolla quinquefid and funnel-shaped, with a cylindrical nectarium within its mouth. There are two species, shrubs of the East Indies.

OPHIRA, a genus of the monogynia order, in the octandria class of plants. The involucrum is bivalvular and triflorous; the corolla is tetrapetalous above; the berry unilocular. There is one species, a shrub of Africa.

OPHITES, in church history, christian hereticks, so called both from the veneration they had for the serpent that tempted Eve, and the worship they paid to a real serpent. They pretended that the serpent was Jesus Christ, and that he taught men the knowledge of good and evil. They distinguished between Jesus and Christ: Jesus they said was born of the Virgin, but Christ came down from heaven to be united with him; Jesus was crucified, but Christ had left him to return to heaven.

OPHRYS, *twyblade*, a genus of the diandria order, in the gynandria class of plants, and in the natural method ranking under the 7th order, orchideæ. The nectarium is a little carinated below. There are 34 species; but the most remarkable are the following: 1. The ovata, oval-leaved ophrys, or common twyblade, has a bulbous fibrated root, crowned by two oval, broad, obtuse, veined, opposite leaves; an erect, succulent, green stalk, six or eight inches high, naked above, and terminated by a loose spike of greenish flowers, having the lip of the nectarium bifid. The flowers of this species resemble the figure of gnats. 2. The Spiralis, spiral orchis, or tripple ladies'-tresses, with a cluster of oval, pointed, ribbed leaves; erect simple stalks, half a foot high, terminated by long spikes of white odoriferous flowers, hanging to one side, having the lip of the nectarium entire, and crenated. 3. The nidus-avis, or bird's-nest; with loose spikes of pale-brown flowers, having the lip of the nectarium bifid. 4. The anthropophora, man-shaped ophrys, or manorchis; with spikes of greenish flowers, representing the figure of a naked man; the lip of the nectarium linear, tripartite, with the middle segment longest and bifid. There is a variety with brownish flowers tinged with green. 5. The insectifera, or insect-orchis, has spikes of insect-shaped greenish flowers, having the lip of the nectarium almost five-lobed. This wonderful species exhibits flowers in different varieties, that represent singular figures of flies, bees, and other insects, and are of different colours in the varieties. 6. The monorchis, or musky ophrys, with a loose spike of yellowish musky-scented flowers.

OPHTHALMIA. See MEDICINE.

OPIUM. See NARCOTIC PRINCIPLE, PAPAVER, and MATERIA MEDICA.

OPOBALSAMUM, or *balm of Gilead*, a resin obtained from amyris Gileadensis, a tree which grows in Arabia, especially near Mecca. It is so much valued by the turks, that it is rarely imported into Europe. Little is therefore known of its composition. It is said to be at first turbid and white, and of a strong aromatic smell, and of a bitter, acrid, astringent taste; but by keeping, it becomes limpid and thin, and its colours change first to green, then to yellow, and at last it assumes the colour of honey.

OPOPONAX, a resin obtained from the pastinaca opoponax, a plant which is a native of the countries round the Levant. The gum-resin is obtained by wounding the roots of the plant. The milky juice, when dried in the sun, constitues the opoponax. It is in lumps of a reddish-yellow colour, and white within: taste bitter and acrid. With water it forms a milky solution. Its specific gravity is 1.62.

OPOSSUM. See DIDELPHIS.

OPPOSITE SECTIONS, are two hyperpolas made by cutting two opposite cones by the same plane. See CONIC SECTIONS.

OPPOSITION, in astronomy, is that aspect or situation of two stars or planets, wherein they are diametrically opposite to each other, or 180° asunder.

OPPOSITION, in geometry, the relation of two things, between which a line may be drawn perpendicular to both.

OPTATIVE MOOD, in grammar, that which serves to express an ardent desire or wish for something. In the English language we have no optative mood.

OPTICS, the science which explains the properties of light.

Optical definitions and principles.

1. Light is a matter, the particles of which are extremely small, and by striking on our visual organs, give us the sensation of seeing.

2. The particles of light are emitted from what are cal-

led luminous bodies, such as the sun, a fire, a torch, or candle, &c. &c. It is reflected or sent back by what are termed opake bodies, or those which have no power of affording light in themselves.

3. Light, whether emitted or reflected, always moves in straight or direct lines, as may easily be proved by looking into a bent tube, which evidently obstructs the progress of the light in direct lines.

4. By a ray of light, is usually meant the least particle of light that can be either intercepted or separated from the rest. A beam of light is generally used to express something of an aggregate or mass of light greater than a single ray.

5. Parallel rays are such as proceed equally distant from each other through their whole course. The distance of the sun from the earth is so immense, that rays proceeding from the body of that luminary are generally regarded as parallel.

6. Converging rays are such as, proceeding from any body, approach nearer and nearer to each other, and tend to unite in a point. The form of rays thus tending to an union in a single point has been compared to that of a candle-extinguisher; it is in fact a perfect cone.

7. Diverging rays are those which, proceeding from a point, continue to recede from each other, and exhibit the form of an inverted cone.

8. A small object, or a small single point of an object, from which rays of light diverge, or indeed proceed in any direction, is sometimes called the radiant, or radiant point.

9. Any parcel of rays, diverging from a point, considered as separate from the rest, is called a pencil of rays.

10. The focus of rays is that point to which converging rays tend, and in which they unite and intersect, or cross each other. It may be considered as the apex or point of the cone; and it is called the focus (or fire-place), because it is the point at which burning-glasses burn most intensely.

11. The virtual or imaginary focus is that supposed point behind a mirror or looking-glass, where the rays would have naturally united, had they not been intercepted by the mirror.

12. Plane mirrors or speculums are those reflecting bodies, the surfaces of which are perfectly plain or even, such as our common looking-glasses. Convex and concave mirrors are those the surfaces of which are curved.

13. An incident ray is that which comes from any body to the reflecting surface; the reflecting ray is that which is sent back or reflected.

14. The angle of incidence is the angle which is formed by the line which the incident ray describes in its progress, and a line drawn perpendicularly to the reflecting surface: and the angle of reflection is the angle formed by the same perpendicular and the reflected ray; thus, (Plate XCVI. Optics, fig. 1) if *ba* is a reflecting surface, and *d c* an incident ray, then *dc* P is the angle of incidence, and *ec* P the angle of reflection.

15. By a medium opticians mean any thing which is transparent, such as void space, air, water, or glass, through which consequently the rays of light can pass in straight lines.

16. The refraction of the rays of light is their being bent, or attracted out of their course, in passing obliquely from one medium to another of a different density, and which causes objects to appear broken or distorted when part of them is seen in a different medium. It is from this property of light that a stick or an oar which is partly immersed in water, appears broken.

17. A lens is a transparent body of a different density from the surrounding medium, commonly of glass, and used by opticians to collect or disperse the rays of light. They are in general either convex, that is, thicker in the middle than at the edges, which collect, and by the force of refraction converge the rays, and consequently magnify; or concave, that is, thinner in the middle than at the edges, which by the refraction disperse the rays of light, and diminish the objects that are seen through them.

18. Vision is performed by a contrivance of this kind. The crystalline humour, which is seated in the fore-part of the human eye, immediately behind the pupil, is a perfect convex lens. As therefore every object is rendered visible by beams or pencils of light, which proceed or diverge from every radiant point of the object, the crystalline lens collects all these divergent rays, and causes them to converge on the back part of the eye, where the retina or optic nerve is spread out; and the points where each pencil of rays is made to converge on the retina, are exactly correspondent to the points of the object from which they proceed. As, however, from the great degree of convergence which this contrivance will produce, the pencils of light proceeding from the extreme points of the object will be made to cross each other before they reach the retina, the image on the retina is always inverted. (See Plate XCVII. fig. 23.)

19. The magnitude of the image painted on the retina will also, it is evident, depend on the greatness or obtuseness of the angle under which the pencil of rays proceeding from the extreme points of the object enters the eye. For it is plain, that the more open or obtuse the angle is, the greater is the tendency of these rays to meet in a point and cross each other; and the sooner they cross each other after passing the crystalline lens, the larger will be the inverted image painted on the retina. (See Pl. XCVII. fig. 24.) The visual angle, therefore, is that which is made by two right lines drawn from the extreme points of any object to the eye; and on the measure of that angle, the apparent magnitude of every visible object will depend.

20. The prism used by opticians is a triangular piece of fine glass, which has the power of separating the rays of light.

History of discoveries. The most ancient hypothesis which leads to the true theory of light and colours, is that of the Platonics, viz. that light, from whatever it proceeds, is propagated in right lines; and that when it is reflected from the surfaces of polished bodies, the angle of reflection is equal to the angle of incidence. To this may be added the opinion of Aristotle, who supposed that rainbows, haloes, and mock suns, were occasioned by the reflection of the sun's beams in different circumstances. We have reason to believe, that the use of convex glasses, both as magnifiers and as burning-glasses, was not unknown to the ancients, though the theory was not understood. The magnifying power of glasses, and some other optical phenomena, were also largely treated

of by Alhazen, an Arabic philosopher of the twelfth century. These observations were followed by those of Roger Bacon, who demonstrated by actual experiment, that a small segment of a glass globe would greatly assist the sight of old persons; and from the hints afforded by these two philosophers, it is not unreasonable to conclude that the invention of spectacles proceeded. Concerning the actual author of this useful invention, we have no certain information: we only find, that it was generally known about the beginning of the fourteenth century.

In the year 1575, Maurolycus, a teacher of mathematics at Messina, published a treatise on optics, in which he demonstrates, that the crystalline humour of the eye is a lens, which collects the rays of light proceeding from external objects, and throws them on the retina, or optic nerve. From this principle he was led to discover the reason of what are called short and imperfect sights. In the one case, the rays converge too soon; in the other, they do not converge soon enough. Hence short-sighted persons are relieved by a concave glass, which causes the rays to diverge in some degree before they enter the eye, and renders it more difficult for them to converge so fast as they would have done after entering the crystalline humour. Hence too he proves that a convex lens is of use to persons who have weak but long sight, by causing the rays to converge sooner, and in a greater quantity, than would otherwise happen. He was the first also that solved a problem which had caused much perplexity in the ancient schools, respecting the sun's image appearing round, though the rays that form it are transmitted into a dark room through an angular aperture. He considered, that as the rays of light are constantly proceeding in every direction, from every part of the sun's disk, "they must be crossing each other from the extreme part of it in every point of the aperture; so that every such point will be the apex of two cones, of which the base of the one is the sun's disk, and that of the other his image on the opposite wall." The whole image, therefore, consists of a number of images, all of which are circular; the image of the sun formed of those images must be circular also; and it will approach the nearer a perfect circle, the smaller the aperture, and the more distant the image.

Nearly about the same time Johannes Baptista Porta, of Naples, invented the camera obscura; and his experiments upon that instrument convinced him that light is a substance, by the intermission of which into the eye, vision is performed; for it is proper to mention, that before his time the opinion was almost general, that vision depended upon what was termed visual rays, proceeding from the eye. In this the system of Porta corresponds nearly with that of Maurolycus: but it ought to be remarked, that the discoveries of each of these two philosophers were unknown to the other. He shows, moreover, that a defect of light is remedied by the dilatation of the pupil, which contracts involuntarily when exposed to a strong light, and opens when the light is faint and languid.

One Fletcher, of Breslau, in 1571, endeavoured to account for the phenomena of the rainbow, by a double reflection and one refraction; but Antonio de Dominis, whose treatise was published in 1611, was the first who came near to the true theory. He describes the progress of the ray of light through each drop of the falling rain; he shows that it enters the upper part of the drop, where it suffers one refraction; that it is reflected once, and then refracted again, so as to come directly to the eye of the spectator: why this refraction should produce the different colours, was reserved for Isaac Newton to explain.

The latter part of the sixteenth century was illustrious for the invention of telescopes. It is generally allowed to have been casual. That effect of refraction, which causes the rays of light, in passing through a dense medium thicker in the middle, to converge to a point, and also that which takes place when they pass through one thicker at the extremities, had been long observed; and the assistance which convex and concave glasses afforded to the sight, had brought them into common use. The inventor of the telescope is not certainly known. The most probable account is, that one Zacharias Jansen, a spectacle-maker of Middleburgh, trying the effect of a concave and convex glass united, found that, placed at a certain distance from each other, they had the property of bringing distant objects apparently nearer to the eye. An account which is very commonly received, is, that some of his children playing in his shop with spectacle-glasses, perceived that when they held two of these glasses between their fingers, at a certain distance from each other, the dial of the clock appeared greately magnified, but in an inverted position. From this their father adopted the idea of adjusting two of these glasses on a board, so as to move them at peasure. Telescopes were greatly improved by Galileo, who constructed one which magnified 33 times, and with this he made all his wonderful astronomical discoveries.

The rationale of telescopes was, however, not explained till Kepler, who described the nature and degree of refraction, when light passed through denser or rarer mediums, the surfaces of which are convex or concave; namely, that it corresponds to the diameter of the circle of which the convexity or concavity are portions of arches. He suggested some improvements in the construction of telescopes, which, however, were left to others to put in practice.

To the Jansens we are also indebted for the discovery of the microscope; an instrument depending upon exactly the same principels as the former. In fact, it is not improbable, that the double lens was first applied to the observation of near but minute objects; and afterwards, on the same principles, to objects which appeared minute on account of their distance.

Much attention was given by Kepler to the investigation of the law of refraction; but he was able to advance no nearer the truth than the observation, that when the incident ray does not make an angle of more than 30 degrees with the perpendicular, the refracted ray proceeds in an angle which is about two-thirds of it. Many disputes arose about the time of Kepler (1600) upon this subject, but it appears that little was effected by them in the cause of truth.

Kepler was more successful in pursuing the discoveries of Maurolycus and B. Porta. He demonstrated that images of external objects were formed upon the optic nerve by the foci of rays coming from every part of the object: he also observed, that these images are inverted; but this circumstance, he says, is rectified by the mind,

which, when an impression is made on the lower part of the retina, considers it as made by rays proceeding from the higher parts of the object. Habit is supposed to reconcile us to this deception, and to teach us to direct our hands to those parts of objects from which the rays proceed. Tycho Brahe, observing the apparent diminution of the moon's disc in solar eclipses, imagined that there was a real diminution of the disc by the force of the sun's rays; but Kepler said, that the disc of the moon does not appear less in consequence of being unenlightened, but rather that it appears at other times larger than it really is, in consequence of its being enlightened. For pencils of rays from such distant objects generally come to their foci before they reach the retina, and consequently diverge and spread when they reach it. For this reason, he adds, different persons may imagine the disc to be of different magnitudes, according to the relative goodness of their sight.

In the sixteenth century also many improvements were made in perspective; the ingenious device, in particular, of the reformation of distorted images by concave or convex speculums was invented, but it is uncertain by whom.

The true law of refraction was discovered by Snellius, the mathematical professor at Leyden; but not living to complete it, the discovery was published and explained by professor Hortensius. Some discoveries of lesser importance were made at this time, among others by Descartes, who very clearly explained the nature and cause of the figure of the rainbow, though he was able to give no account of the colours; he however considered the small portion of water, at which the ray issues, as having the effect of a prism, which was known to have the property of exhibiting the light, transmitted through it, coloured.

In 1625, the curious discovery of Scheiner was published at Rome, which ascertains the fact, that vision depends upon the images of external objects upon the retina. For taking the eye of an animal, and cutting away the coats of the back part, and presenting different objects before it, he displayed their images distinctly painted on the naked retina or optic nerve. The same philosopher demonstrated by experiment, that the pupil of the eye is enlarged in order to view remote objects, and contracted when we view those which are near. He showed, that the rays proceeding from any object, and passing through a small hole in a pasteboard, cross one another before they enter the eye; for if the edge of a knife is held on the side next the eye, and is moved along till it in part covers the hole, it will first conceal from the eye that part of the object which is situated on the opposite side of the hole.

Towards the middle of the seventeenth century the velocity of light was discovered by some members of the Royal Academy of Sciences at Paris, particularly Cassini and Roemer, by observing the eclipses of Jupiter's satellites. About the same time Mr. Boyle made his experiments on colours. He proved that snow did not effect the eye by a native, but reflected light, a circumstance which, however, at this day, we should scarcely believe was ever necessary to be proved by experiment. By admitting also a ray of light into a dark room, and letting it fall on a sheet of paper, he demonstrated, that white reflected much more light than any other colour; and to prove that white bodies reflect the rays outwards, he adds, that common burning-glasses will not, for a long while, burn or discolour white paper; on the contrary, a concave mirror of black marble did not reflect the rays of the sun with near so much power as a common concave mirror. The same effect was verified by a tile, one half of the surface of which was white, and the other black.

Some experiments were made about this time on the difference of the refractive powers of bodies; and the first advance to the great discoveries by means of the prism was made by Grimaldi, who observed that a beam of the sun's light, transmitted through a prism, instead of appearing round on the opposite wall, exhibited an oblong image of the sun. Towards the close of this century the reflecting telescope was invented by our countryman James Gregory. It was, however, only an idea conceived by him upon theory, and the first reflecting telescope was made by Newton.

The reader will soon perceive how very imperfect all the preceding discoveries were in comparison with those of sir Isaac Newton. Before this time, little or nothing was known concerning colours; even the remark of Grimaldi respecting the oblong figure of the sun, made by transmitting the rays through a prism, was unknown to our great philosopher, having been published only the year before. This fact, however, which he had observed himself, was, it appears, the first circumstance which directed the attention of Newton to the investigation of the theory of colours. Upon measuring the coloured image, which was made by the light admitted into a dark chamber through a prism, he found that its length was five times greater than its breadth. So unaccountable a circumstance induced him to try the effect of two prisms, and he found that the light, which by the first prism was diffused into an oblong, was by the second reduced to a circular form, as regularly as if it had passed through neither of them. After many conjectures and experiments relative to the cause of these phenomena, he at length applied to them what he calls the experimentum crucis. He took two boards, and placed one of them close to the window, so that the light might be admitted through a small hole made in it, and after passing through a prism might fall on the other board, which was placed at about twelve feet distance, and in which there was also a small aperture, in order that some of the incident light might pass through it. Behind this hole, in the second board, he also placed a prism, so that the light, after passing both the boards, might suffer a second refraction before it reached the wall. He then moved the first prism in such a manner as to make the several parts of the image cast upon the second board pass successively through the hole in it, that he might observe to what places on the wall the second prism would refract them. The consequence was, that the coloured light, which formed one end of the image, suffered a refraction considerably greater than that at the other end; in other words, rays or particles of light of one colour were found to be more refrangible than those of another. The true cause, therefore, of the length of the image was evident; since it was proved by the experiment, that light was not homogeneal, but consisted

of different particles or rays, which were capable of different degrees of refrangibility, according to which they were transmitted through the prism to the opposite wall. It was further evident from these experiments, that as the rays of light differ in refrangibility, so they also differ in exhibiting particular colours, some rays producing the colour red, others that of yellow, blue, &c. and of these different-coloured rays, separated by means of the prism according to their different degrees of refrangibility, the oblong figure on the wall was composed. But to relate the great variety of experiments, by which he demonstrated these principles, or the extensive application of them, would lead us too much into detail; let it suffice to say, that he applied his principles to the satisfactory explanation of the colours of natural bodies, of the rainbow, and of most of the phenomena of nature where light and colour are concerned; and that almost every thing which we at present know upon these subjects was laid open by his experiments.

His observations on the different refractive powers of different substances are curious and profound; but chemistry was at that period scarcely in a state sufficiently advanced to warrant all his conclusions. The general result is, that all bodies seem to have their refractive powers proportional to their densities, excepting so far as they partake more or less of inflammable or oily particles.

The discovery of the different refrangibility of the component rays of light suggested defects in the construction of telescopes, which were before unthought of, and in the creative hand of a Newton led to some no less extraordinary improvements in them. It is evident, that since the rays of light are of different refrangibilities, the more refrangible will converge to a focus much sooner than the less refrangible, consequently that the whole beam cannot be brought to a focus in any one point; so that the focus of every object-glass will be a circular space of considerable diameter, namely, about one fifty-fifth of the aperture of the telescope. To remedy this, he adopted Gregory's idea of a reflector, with such improvements as have been the basis of all the present instruments of this kind.

When a science has been carried to a certain degree of perfection, subsequent discoveries are too apt to be considered as of little importance. The real philosopher will not, however, regard the discoveries on light and colours, since the time of Newton, as unworthy his attention. By a mere accident, a very extraordinary property in some bodies of imbibing light, and afterwards emitting it in the dark, was observed. A shoemaker of Bologna, being in quest of some chemical secret, calcined, among other things, some stones of a particular kind, which he found at the bottom of Mount Peterus; and casually observed, that when these stones were carried into a dark place, after having been exposed to the light, they possessed a self-illuminating power. Accident afterwards discovered the same property in other substances. Baldwin, of Misnia, dissolving chalk in aquafortis, found that the residuum, after distillation, exactly resembled the Bolognian stone in retaining and emitting light, whence it now has the name of Baldwin's phosphorus; and M. Du Fay observed the same property in all substances that could be reduced to a calx by burning only, or after solution in nitrous acid. These facts seem to establish the materiality of light.

Some very accurate calculations were made about the year 1725 by Dr. Bradley, which afforded a more convincing proof of the velocity of light, and the motion of the earth in its orbit. Nor must we forget M. Bouguer's very curious and accurate experiments for ascertaining the quantity of light which was lost by reflection, the most decisive of which was by admitting into a darkened chamber two rays of light, one of which he contrived should be reflected, and the other fall direct on the opposite wall; then by comparing the size of the apertures by which the light was admitted (that through which the direct ray proceeded being much smaller than that through which the reflected rays was suffered to pass, and the illumination on the wall being equal in both), he was enabled to form an exact estimate of the quantity of light which was lost. To prove the same effect with candles, he placed himself in a room perfectly dark, with a book in his hand, and having a candle lighted in the next room, he had it brought nearer to him till he could just see the letters, which were then 24 feet from the candle. He then received the light of the candle reflected by a looking-glass upon the book, and he found the whole distance of the book from the source of the light (including the distance from the book to the looking-glass) to be only 15 feet; whence he concluded, that the quantity of direct light is to that of reflected as 576 to 225; and similar methods were pursued by him for measuring the proportions of light in general.

The speculations of Mr. Melville concerning the blue shadows which appear from opaque bodies in the morning and evening, when the atmosphere is serene, are far from uninteresting. These phenomena he attributes to the power which the atmosphere possesses of reflecting the fainter and more refrangible rays of light, the blue, violet, &c. and upon this principle he also explained the blue colour of the sky, and some other phenomena.

The same period produced Mr. Dollond's great improvement in the construction of telescopes. It consists in using three glasses of different refractive powers, crown and flint glass, which correct each other. The great dispersion of the rays which the flint-glass produces, is the effect of the lead, and is in proportion to the quantity of that metal which is used in its composition. Mr. Martin found the refractive powers of different glasses to be in proportion to their specific gravity.

Several discoveries and improvements have been made since the time of Newton in that branch of optics which relates more immediately to vision. One of these is not only curious in itself, but led to the explanation of several circumstances relating to vision. M. De la Motte, a physician of Dantzick, was endeavouring to verify an experiment of Scheiner, in which a distant object appeared multiplied when viewed through several holes made with the point of a pin in a card, not farther distant from one another than the diameter of the pupil of the eye; but notwithstanding all his labour, he was unable to succeed, till a friend happening to call upon him, he desired him to make the trial, and it answered perfectly. This friend was short-sighted; and when he applied a concave glass close to the card, the object, which seemed multiplied before, now appeared but one.

The last, though not least, successful adventurer in this branch of science, is Mr. Delaval, who, in a paper read before the Philosophical Society of Manchester, in 1784, has endeavoured, with great ingenuity, to explain the permanent colours of opaque bodies. The majority of those philosophers, who have treated of light and colours, have, he observes, supposed that certain bodies or surfaces reflected only one kind of rays, and therefore exhibited the phenomena of colours; on the contrary, Mr. Delaval, by a variety of well-conducted experiments, evinced, that colours are exhibited, not by reflected, but by transmitted light. This he proved by covering coloured glasses and other transparent coloured media, on the further surface, with some substance perfectly opaque, when he found they reflected no colour, but appeared perfectly black. He concludes, therefore, as the fibres or bases of all vegetable, mineral, and animal substances, are found, when cleared of heterogeneous matters, to be perfectly white; that the rays of light are in fact reflected from these white particles, through coloured media, with which they are covered; that these media serve to intercept and impede certain rays in their passage through them, while, a free passage being left to others, they exhibit, according to these circumstances, different colours. This he illustrates by the fact remarked by Dr. Halley, who, in diving deep into the sea, found that the upper part of his hand, when extended into the water from the diving-bell, reflected a deep-red colour, while the under part appeared perfectly green. The conclusion is, that the more refrangible rays were intercepted and reflected by particles contained in the sea-water, and were consequently reflected back by the under part of the hand; while the red rays, which were permitted to pass through the water, were in the same manner reflected by the upper part of the hand, which therefore appeared of a red rose-colour. Those media, our author thinks, transmit coloured light with the greatest strength, which have the strongest refractive power.

Of the nature of light. Numerous opinions have successively been adopted concerning this wonderful fluid. It has been sometimes considered as a distinct substance, sometimes as a quality, sometimes as a cause, frequently as an effect; by some regarded as a compound, and by others as a simple substance. Descartes and other philosophers of high repute, have imagined that the sensation which we receive from light is to be attributed entirely to the vibrations of a subtile medium or fluid, which is diffused throughout the universe, and which is put into action by the impulse of the sun. In this view they consider light as analogous to sound, which is known to depend entirely on the pulsations of the air upon the auditory nerves; and in support of this opinion, it has been even lately urged, 1st, That some diamonds, on being rubbed or chafed, are luminous in the dark. 2. That an electric spark, not larger, but much brighter, than the flame of a candle, may be produced, and yet that no part of the electric fluid is known to escape, in such a case, to distant places, but the whole proceeds in the direction to which it is destined by the hand of the operator. Weaker or stronger sparks of this fluid are also known to differ in colour; the strongest are white, and the weakest red, &c.

To this opinion, however, there are many pressing, and, indeed, insurmountable objections. 1st, The velocity of sound bears a very small proportion to that of light. Light travels, in the space of eight minutes, a distance in which sound could not be communicated in 17 years; and even our senses may convince us, if we attend to the explosion of gunpowder, &c. of the almost infinite velocity of the one compared with that of the other. 2dly, If light depended altogether on the vibrations of a fluid, no solid reason can be assigned why this fluid should cease to vibrate in the night, since the sun must always affect some part of the circumambient fluid, and produce a perpetual day. 3dly, The artifice of candles, lamps, &c. would be wholly unnecessary upon this hypothesis, since, by a quick motion of the hand, or of a machine contrived for this purpose, light might on all occasions be easily produced. 4thly, Would not a ray of light, admitted through a small aperture, put in motion, according to this theory, the whole fluid contained in a chamber? In fact, we know that light is propagated only in right lines; whereas sound, which depends upon vibration, is propagated in every direction. 5thly, The separation or extension of the rays, by means of the prism, can never be accounted for by the theory of a vibrating medium. 6thly, The texture of many bodies is actually changed by exposure to the light. The juice of a certain shell-fish contracts, it is well known, a very fine purple colour, when permitted to imbibe the rays of the sun; and the stronger the light is, the more perfect the colour. Pieces of cloth wetted with this fluid become purple, even though inclosed in glass, if the solar light only is admitted; but the effect is totally prevented by the intervention of the thinnest plates of metal, which exclude the light. Some of the preparations of silver, as luna cornea, will remain white if covered from the light, but contract a dark-purple colour when exposed to it; and even the colour of plants is derived from the light, since a plant which vegetates in darkness will be perfectly white. As colour is imparted by light, so it is also destroyed by it. It must have fallen within the observation of every reader, that silks and other stuffs of delicate colours, are greatly affected by the action of light. Experiments have been made upon the same stuffs by exposing them to both heat and moisture in the dark, and also by exposing them to the light in the vacuum of an air-pump, and it was found by all these experiments, that the change of colour was to be ascribed to the action of light. 7thly, With respect to the emission of light by diamonds and other stones, it is easily accounted for upon other principles; and the arguments founded upon the electric spark not being sensibly diminished, will meet with a satisfactory solution by considering the extreme rarity of light, and the minuteness of its particles.

It is, therefore, almost universally agreed by the moderns, that light consists of a number of extremely minute particles, which are actually projected from the luminous body, and act by their projectile force upon the optic nerve. Concerning the nature of these particles, or rather of the matter of which they consist, there is less unanimity in the philosophical world.

The first remarkable property of light is its amazing velocity. In the short space of one second a particle of light traverses an extent of 170,000 miles, which is

so much swifter than the progress of a cannon-ball, that the light is enabled to pass a space in about eight minutes which could not be passed with the ordinary velocity of a cannon-ball in less than 32 years. The velocity of light is also found to be uniform, whether it is original, as from the sun, or reflected only, as from the planets.

The mode of calculating the velocity of light is a branch of astronomy. It will suffice, therefore, in this place to remark, that by mathematical observations made upon the transits of Venus in 1761 and 1769, the diameter of the earth's orbit was found to be about 163,636,800 geographical miles. When, therefore, the earth happens to be on that side of her orbit which is opposite to Jupiter, an eclipse of his satellites, or any other appearance in that planet, is observed to take place 15 or 16 minutes later than it would have done if the earth had been on that side of her orbit which is nearest to Jupiter. From the very accurate observations of Dr. Bradley, it appears, that the light of the sun passes from that luminary to the earth in eight minutes and twelve seconds.

The next property of light to which it is proper to advert is, that it is detached from every luminous or visible body in all directions, and constantly moves in right lines. It is evident that the particles of light move continually in right lines, since they will not pass through a bended tube; and since if a beam of light is in part intercepted by any intervening body, the shadow of that body will be bounded by right lines passing from the luminous body, and meeting the lines which terminate the interceding body. This being granted, it is obvious, that the rays of light must be emitted from luminous bodies in every direction; since, whatever may be the distance at which a spectator is placed from any visible object, every point of the surface which is turned towards him is visible to him, which could not be upon any other principle.

The rarity of light, and the minuteness of its particles, are not less remarkable than its velocity. If indeed the Creator had not formed its particles infinitely small, their excessive velocity would be destructive in the highest degree. It was demonstrated, that light moves about two millions of times as fast as a cannon-ball. The force with which moving bodies strike, is in proportion to their masses multiplied by their velocities; and consequently, if the particles of light were equal in bulk to the two-millionth part of a grain of sand, we should be no more able to endure their impulse than that of sand shot point-blank from the mouth of a cannon. The minuteness of the rays of light is also demonstrable from the facility with which they penetrate glass, chrystal, and other solid bodies, which have their pores in a rectilinear direction, and that without the smallest diminution of their velocity, as well as from the circumstance of their not being able to remove the smallest particle of microscopic dust or matter which they encounter in their progress. A further proof might be added, that if a candle is lighted, and there is no obstacle to obstruct its rays, it will fill the whole space within two miles around it almost instantaneously, and before it has lost the least sensible part of its substance.

To the velocity with which the particles of light are known to move, may in a great measure be attributed the extreme rarity and tenuity of that fluid. It is a well-known fact, that the effect of light upon the eye is not instantaneous, but continues for a considerable time. Now we can scarcely conceive a more minute division of time than the 150th part of a second. If, therefore, one lucid point of the sun's surface emits 150 particles of light in one second, we may conclude that this will be sufficient to afford light to the eye without any seeming intermission; and yet, such is the velocity with which light proceeds, that still these particles will be at least 1000 miles distant from each other. If it was not indeed for the extreme tenuity of the fluid, it would be impossible that the particles should pass, as we know they do, in all directions without interfering with each other. In all probability the splendour of all visible objects may be in proportion to the greater or less number of particles which are emitted or reflected from their surface in a given space of time; and if we even suppose 300 particles emitted successively from the sun's surface in a single second, still these particles will follow each other at the immense distance of above 500 miles.

Of the reflection of light, or *catoptrics*. It has been already intimated, that the rays of light which proceed from any luminous body move always in straight lines, unless this direction or motion is changed by certain circumstances; and these are reflection, refraction, and inflection.

The great law of reflection, and which serves to explain all its phenomena, is this, that the angle of reflection is always equal to the angle of incidence. It has been already intimated, that by the angle of incidence is meant the angle made by a ray of light with a perpendicular to the reflecting surface at the point where the ray falls; and by the angle of reflection, the angle which the ray makes with the same perpendicular on the other side.

A ray of light falling perpendicularly on a plane surface, is reflected back exactly in the same direction in which it came to the reflecting surface: rays falling obliquely observe the general law of reflection, and their angle of reflection is exactly equal to the angle of incidence. In Plate XCVI. Optics, fig. 1. *fc* is a ray of light falling perpendicularly on the plane surface *ab*, and it is reflected back exactly in the same direction; *ec* is a ray falling obliquely on the surface at *c*, and it is reflected in the direction *cd*, making the angle of reflection *cd* P exactly equal to the angle of incidence *ce*P, as may be seen by inspection of the figure.

Parallel rays falling obliquely on a plane reflecting surface are reflected parallel, converging rays are reflected with the same degree of convergence, and diverging rays equally diverging. In other words, plane surfaces or mirrors make no change in the previous disposition of the rays of light.

A mirror is a body, the surface of which is polished to such a degree as to reflect most copiously the rays of light. Figs. 1, 2, 3, are plane mirrors: in fig. 2. the rays *db* and *ca*, which are parallel, after having reached the surface *ab* are reflected, the one towards *h* and the other towards *k*, and in both instances the angle of reflection is evidently equal to the angle of incidence.

The rays *db* and *ca* (fig. 3.) are convergent, and with-

out the interposition of the mirror would unite in the point E; but being reflected, they unite in the opposite point F: the angle of reflection with respect to each being still equal to the angle of incidence, as may be seen by drawing perpendiculars to the points *a* and *b*.

The rays *db* and *ca* (fig. 4.) are on the contrary divergent, and after reflection towards *h* and *k*, preserve exactly the same distance from each other as they would have had if they had proceeded without interruption towards F and E, the angle of reflection being with respect to each ray still exactly equal to the angle of incidence.

Thus it is that plane surfaces reflect the rays of light; but the effects are materially different when the surfaces are convex or concave, though the same law still obtains with respect to these. From a convex surface, parallel rays, when reflected, are made to diverge; convergent rays are reflected less convergent, or are even made to diverge in proportion to the curvature of the surface compared with their degree of convergence; and divergent rays are rendered more divergent. Thus it is the nature of convex surfaces to scatter or disperse the rays of light, and in every instance to impede their convergence. From a concave surface, on the contrary, parallel rays when reflected are made to converge; converging rays are rendered more convergent; and diverging rays are made less divergent, or even in certain cases may be made to converge.

To understand this part of the subject, it is necessary to be aware, that all curvilinear surfaces are composed of right lines infinitely short, or points; and the reader will recollect, that only those rays which fall perpendicularly on a reflecting surface are reflected back in the same direction. All curves, are arches or segments of circles: if therefore any curvilinear or spherical surface is presented to a number of parallel rays, it is evident that only that ray which strikes the spherical surface in such a direction that it would proceed in a right line to the centre of that circle, of which the reflecting surface is an arch or segment, can be said to fall perpendicularly upon it, of which the reader may convince himself by drawing a straight line with a ruler at any point of a given circle or curve. All the rest of the parallel rays, therefore, falling on the spherical surface, will fall obliquely upon it, and will consequently be subject to the general law of reflection, and the angle of their reflection will be equal to the angle of their incidence.

Perhaps the subject will be rendered still plainer, if, pursuing the idea thrown out in the preceding paragraph, that all curves are formed of a number of straight lines infinitely short, and inclining to each other like the stones in the arch of a bridge, we present to the reader the figures 5, 6, 7; which may be imagined so many mirrors bent or inclined in the form which is represented in the plate. The rays *ab* and *cd* (fig. 5.), which are parallel, are from their different points of incidence rendered divergent in *h* and *e*; the angle of reflection with respect to each being equal to the angle of incidence.

In fig. 6. the rays *ab* and *cd* are convergent, and would, without the interposition of the reflecting surface *bd*, unite in *m*; but according to the same principle, they now proceed to unite in *l*, which is more distant from the reflecting surface than the point *m*; and it is evident, that if the curvature of the two branches of the reflecting surface *b* and *d* was greater, they might be reflected parallel, or even divergent. In the same manner, as in fig. 7., the rays *ab* and *cd*, which, without the interposition of the convex surface *bd*, would diverge but very little at *m*, become after reflection much more divergent at *l*; and the angles of reflection will be found in all these cases exactly equal to the angles of incidence, if measured from the reflecting surface produced or lengthened, as at *fg* and *ik*.

Let now fig. 8 represent a concave mirror formed upon the same principles as those which we have been examining of the convex kind. The rays *ab*, *cd*, which were parallel before reflection, and which make their angles of reflection equal to their angles of incidence (measured for convenience in this figure from the reflecting surface produced), become evidently convergent at the point *l*; upon the same principles in fig. 9. the converging rays *ab* and *cd*, which would not have united before they reached the point *m*, are now after reflection united at *l*, which is much nearer the reflecting surface. In fine, the divergent rays *ab* and *cd* in fig. 10., which would have become more divergent at *m*, had they not been intercepted by the reflecting surface, become convergent after reflection, and are found actually to unite at *o*.

Mirrors are formed either of metal, or of glass plated behind with an amalgam of mercury and tin. The latter are most in common use; but they are improper for optical instruments, such as telescopes, &c. because they commonly present two images of the same object, the one vivid and the other faint, as may be perceived by placing the flame of a wax-taper before a common looking-glass. The reason of this double image is, that a part of the rays are immediately reflected from the anterior surface of the glass, and thus form the faint image; while the greatest part of the rays penetrating the glass are reflected by the amalgam, and form the vivid image.

From the principles laid down, most of the phenomena of reflection may be explained. In plane mirrors, the image appears of its natural size, and at the same distance behind the glass as the object is before it. To understand perfectly the reason of this, it will be necessary to advert to the subject of vision, as formerly explained. It will be remembered, that by the spherical form of the eye, and particularly by means of the chrystalline humour which is placed in the middle of it, the rays of light are converged; and those from the extreme points of the object cross each other, so as to form an inverted image on that part of the optic nerve which is called the retina. The apparent magnitude of objects will consequently depend upon the size of the inverted image, or, in other words, upon the angle which the rays of light form, by entering the eye from the extremities of any object.

As therefore the angle of reflection is always equal to the angle of incidence, it will be evident on the inspection of fig. 11. that the converging rays K*m*, L*n*, proceeding from the extremities of the object KL, and falling on the mirror *ab*, are reflected to the eye at *e* with the same degree of convergence, and consequently will cause the image *kl* to be seen under an angle equal to that under which the object itself would have been seen

from the point i without the interposition of the mirror. The image appears also at a distance behind the mirror equal to that at which the object stands before it. For it must be remembered, that objects are rendered visible to our eyes not by a single ray proceeding from every point of an object, but that in fact pencils or aggregates of divergent rays proceed from every point of all visible objects, which rays are again, by the mechanism of the eye, converged to as many points on all those parts of the retina where the image is depicted. The point from which the rays diverge is called the focus of divergent rays; and the point behind a reflecting surface from which they appear to diverge, is called the virtual focus. As therefore the angle of reflection is exactly equal to the angle of incidence, it is evident that the virtual focus will be at the same distance behind the mirror as the real focus is at before it. Thus, in fig. 12., the diverging rays ch will after reflection appear to diverge from the point g which is behind the mirror ab, and that point for the reasons assigned (viz. no alteration being made in the disposition of the rays but only in the direction) will be at an equal distance behind the mirror with the luminous point c before it.

As every part of the image appears at a distance behind the mirror equal to that at which the object stands before it, and as the object KL (fig. 11.) is inclined or out of the vertical position, the image kl appears also inclined. Hence it is evident, that to exhibit objects as they are without any degree of distortion, looking-glasses should be always hung in a vertical position, that is, at right angles with the floor of the apartment.

It is clear, however, from what has preceded, that the case must be very different with those mirrors, the surfaces of which are spherical, whether convex or concave. Of the former it has been shown that their property is to scatter and disperse the rays of light, to render those divergent which were parallel, to diminish the convergence of converging rays, and to augment the divergence of those which diverged before. The first obvious effect of these mirrors, therefore, must be to exhibit the image of the object which is opposed to them smaller than it is in reality. For the angle under which the rays strike the eye of the observer, must necessarily be smaller in proportion to the convexity of the mirror. Suppose, for instance, the object CD (fig. 13.) placed before the convex mirror ab; the two rays Cc and Dd, which proceed from the extremities of the object, and which, without the interposition of the mirror, would converge at f, are reflected less convergent, and unite at i, forming an angle much more acute than they would otherwise have done. The consequence, therefore, of the visual angle being so much more acute, is, that the image gh is proportionally smaller than the object itself.

The second effect of this dispersion of the rays is, that the image appears at a less distance behind the glass than it would have done in a plane mirror. To understand this effect, it is necessary again to advert to a principle of optics which has been just stated, viz. that objects are rendered visible not by a single ray of light proceeding from every point of the object, but that from every minute point of the surface of every visible object pencils of divergent rays proceed, which are again converged on the retina of the spectator's eye.

Suppose then G (fig. 14.) a luminous point of any visible object, from which a pencil of divergent rays proceed, and fall upon the convex mirror ab: these rays, agreeably to the nature of these mirrors, are reflected more divergent, and have their fictitious point of re-union (or virtual focus) g much nearer to the eye and to the surface of the mirror, than they would otherwise have. The image therefore, as may be seen in the figure, instead of being at a distance behind the mirror equal to the distance at which the object stands before it (as would be the case in a plane mirror), will appear at a smaller distance, and this distance will always be diminished in proportion to the convexity of the mirror.

For the same reasons an object of a certain size, placed either perpendicularly or obliquely before a convex mirror, will necessarily appear curved or bent, because the different points of the object are not at equal distances from the surface of the mirror. All these effects will be very apparent from inspecting one of those small glass globes, lined with the common amalgam for making looking-glasses, which are sometimes suspended in old-fashioned apartments. In these the company seated in the room or round the table, are represented by very minute images, which appear not at a certain distance behind as in plane looking-glasses, but very near the surface of the mirror, and always in some degree curved or distorted.

The effects and phenomena of concave mirrors will obviously, from what has been said, be the direct contrary to those of the convex kind. The surface of concave mirrors is generally spherical (or in the form of a globe); though that is not always the most convenient form for optical purposes, but it is that which is least difficult to the workmen.

The general effect of concave mirrors is, we have already seen, to render the rays more convergent. The point in which the converged rays unite is called the focus of converging rays; but this focus cannot be the same for all the rays incident on a concave surface. The parallel rays, ab, de (fig. 15.), are converged by the mirror at the point F, which is distant from the mirror one-fourth part of the diameter of that circle, of which the mirror is a part or section; and this is the point which is called the focus of parallel rays, and it is the real or principal focus of the mirror. The converging rays fg, hi, are reflected upon the same principles more convergent, and unite at the point K, nearer to the surface of the mirror than the principal focus. In fine, the divergent rays Rm and Ro, which proceed from the point R, beyond the principal focus, unite at the point P. But if the point of divergence was nearer the mirror than the principal focus, as for instance at K, they would still be reflected divergent, and would proceed one towards f and the other towards h.

Plane and convex mirrors exhibit, as has been already mentioned, the image behind the glass or mirror, and in a situation conformable to that of the object; but concave mirrors show the image behind when the object is placed between the principal focus and the mirror, and then the image is larger than the object. Let AB (fig. 16.) be the object placed before the concave mirror EF, and nearer

to the mirror than its principal focus. The two pencils of rays Ae, Bf, which proceed from the extremities of the object, and which without the interposition of the mirror, would converge at d, are reflected more converging, and unite at D; and making an angle greater or more obtuse than they would otherwise have done, the image ab is consequently greater than the object.

This image too appears at a greater distance behind the mirror than the object is at before it. The reason of this will appear, if we suppose A (fig. 17.) a point of any object placed nearer to the mirror than the principal focus F, whence a pencil of divergent rays proceed, and falling on the mirror, are (according to the principles before laid down) reflected less divergent, and consequently have their virtual or imaginary focus at a greater distance, than if the object had been placed before a plane mirror.

If, on the contrary, the object is placed farther from the mirror than the principal focus, as for instance at e, the rays eb, ed, being only moderately divergent when they come in contact with the mirror, are reflected convergent, and will represent at E an image of the object. If the eye, therefore, is withdrawn to a sufficient distance (to o for example) for the rays to cross each other, it will perceive the image suspended in the air at E between the mirror and itself. The reason of this depends upon what has been already stated. Every object is rendered visible to us by pencils of divergent rays from every point of that object; it therefore ceases to be visible if these rays are converged to a point, and this happens when the object is not nearer to the mirror than the principal focus. To render, therefore, an object thus situated visible, it is necessary that the eye should recede so far beyond the place of the image E, as to allow the rays to cross each other, and meet the eye in a state of divergence.

The image is in this case always inverted. Such is the image ba of the object AB (fig. 18.) From this property of the concave reflector to form the image of an object, in these cases, before the reflector, many deceptions have been produced, to the great surprise of the ignorant spectator. He is made to see a bottle half-full of water inverted in the air without losing a drop of its contents; as he advances into a room, he is tempted to exclaim with Macbeth, "Is this a dagger that I see before me?" and when he attempts to grasp it, it vanishes into the air.

A variety of similar appearances may be represented, which are all produced by means of a concave mirror, having an object before it strongly illuminated, care being taken that only the rays of light reflected from the object shall fall upon the concave reflector, placed in such a manner that the image shall be in the middle of the adjoining room; or, if in the same room with the object and reflector, a screen must be placed so as to prevent the spectator from discovering them. A hole is then made in the partition between the two rooms, or in the screen, through which the rays pass by which the image is formed. The spectator then, when he casts his eyes upon the partition of the screen, will, in certain situations, receive the rays coming through this small aperture. He will see the image formed in the air; he will have no idea, if not previously acquainted with optics, of the nature of the deception; and may either be amused, according to the inclination of his friends, with tempting fruit, or be terrified at the sight of a ghastly apparition.

Since it is the property of a concave mirror to cause those rays which proceed in a parallel direction to its surface, to converge to a focus; and since the solar rays, from the immense distance of that body, may be considered as parallel; concave mirrors prove very useful burning glasses: and the focus of parallel rays, or principal focus, is their focus or burning-point.

Cylindrical mirrors, such as that represented in fig. 19. are employed more for the purpose of amusement than of philosophy. They are called mixed mirrors, because they produce at the same instant the effects of plain and of convex mirrors. Suppose, for instance, GF (fig. 20.) to be the height of such a mirror, and AE an object placed before or rather below it; all the rays which proceed from the points A, B, C, D, E, falling on the surface GF of the mirror, and reflected to the eye at O, will represent the images of these different points at a, b, c, d, e, as they would be represented in a plane mirror; and with respect to these, the dimensions of the object will not be altered in the corresponding image. But since the mirror is also curved, if we suppose the space q, t, y, (fig. 21.) to represent a part of its circumference, the rays Aq, Lr, Ms, Nt, Ox, Pz, Fy, being reflected to the eye at Z, will exhibit all these points A, L, M, N, &c. within the space af; which will in this direction diminish considerably the dimensions of the image, according to the principles already explained in treating of the convex mirror, viz. by diminishing the convergence of rays, and consequently reducing the size of the image in proportion to the convexity. In the cylindrical mirror, it must be observed, that it is in the breadth only that this diminution takes place. The same will take place with respect to all the points of the object which are visible within the lines BQG, CRH, DTI, ESK, concentric to the surface of the mirror. These parts must therefore be very much extended in the drawing or design, if a perfect image is to be represented in the mirror. Distorted drawings of this kind are common in the shops of the opticians, which, on a cylindrical mirror being placed on the board or drawing, display perfect figures. The principle of these will, however, be very easily understood from what has been now stated.

The conical mirror is represented in fig. 22, and this is also considered as a mixed mirror; for, as well as the cylindrical, it produces at once the effects of a convex and a plane mirror. Suppose, for instance, the angle C KF (fig. 23.) to represent this mirror, and the lines C K, FK, two of the right lines which compose it. These two lines would then answer to two plane mirrors inclined towards each other: and the rays proceeding from the points ABC, falling on the surface at g, h, i, and reflected towards the eye at O, would represent these points as if at the base of the mirror in the opposite order a, b, c; and the same observation will apply to the points D, E, F, which are represented at d, e, f, as well as all those which are in the circles AHD, BIE, CGF. But as there do not proceed from each point simple rays of light, but pencils of rays, they are modified in this mirror upon the same principles as in the convex mirror; and consequently the image will appear smaller than the object, and nearer to the eye, than in the plane mirror.

Hence it will be evident, that we may see in the centre the image of whatever is painted on the exterior circumference AHD, and the extremities of the image will be formed from the interior circle CGF; and as the curvature or convexity of the mirror is greater towards the apex or point of the cone, it follows, that that which is the most extended in the object will be the most compressed or concentrated in the image. Thus the dark part of the board (fig. 24.) is intended to represent in the mirror an ace of spades; and the points *a, b, c, d, e, f, g,* &c. which are nearest to the mirror, form the outer circumference of the image; and the points 1, 2, 3, 4, 5, 6, 7, 8, of the external circumference of the board, unite in the centre of the image at an almost imperceptible point.

Of the refraction of light, or *dioptrics.* It has been proved that light, like every known substance, is subject to the laws of attraction; it has been intimated too, that even its propensity to move in a direct line is, in certain cases, overcome by this superior influence; and that the direction of the rays of light is changed in passing from one medium to another. The space in which a ray of light moves is called a medium; whether pure space, air, water, glass, or any other transparent substance; and when a ray is bent out of its natural course in passing from one medium to another, it is said to be refracted or broken, probably from the broken appearance which a staff, &c. exhibits when part of it is immersed in water.

There are two circumstances essential to refraction: 1st, That the rays of light shall pass out of one medium into another of a different density, or of a greater or less degree of resistance. 2dly, That they pass in an oblique direction.

The denser the refracting medium, or that into which the ray passes, is, the greater will be its refracting power; and of the two refracting mediums of the same density, that which is of an oily or inflammable nature will have a greater refracting power than the other.

The angle of refraction depends on the obliquity of the rays falling on the refracting surface being such always, that the sine of the incident angle is to the sine of the refracted angle in a given proportion.

The incident angle is the angle made by a ray of light, and a line drawn perpendicular to the refracting surface, at the point where the light enters the surface; and the refracted angle is the angle made by the ray in the refracting medium with the same perpendicular produced. The sine of the angle is a line which serves to measure the angle, being drawn from a point in one leg perpendicular to the other.

In passing from a rare into a dense medium, or from one dense medium into a denser medium, a ray of light is refracted towards the perpendicular, that is, so that the angle of refraction shall be less than the angle of incidence; on the contrary, in passing from a dense medium into a rare medium, or from one rare medium into a rarer, a ray of light is refracted from the perpendicular. Thus, in passing from empty space into air, or any other medium whatever, the ray is bent towards the perpendicular; and in passing from any other medium into a pure space, it is bent the contrary way, that is, from the perpendicular; the same effects will take place in passing from air into glass, and from glass into air, &c.

To render this perfectly clear, let us have recourse to fig. 25. If a ray of light *p*G passes from air to water, in the direction *p*G, perpendicular to the plane D*d*, which separates the two mediums, it suffers no refraction, because one of the essentials is wanting to that effect, viz. the obliquity of the incidence.

But if a ray AG passes obliquely from air into water, instead of continuing its course in the direct line GB, it takes the direction G*a*, and approaches the perpendicular *p*P, in such a manner that the angle of refraction PG*a* is less than its angle of incidence *p*GA.

If the ray came in a more oblique direction, the refraction would be still greater; so that in all cases where the mediums are the same, the angle of refraction will always be found to bear a regular and constant proportion to the angle of incidence; or, to speak in technical language, the sine of incidence is to the sine of refraction in a given ratio, and this ratio is discovered by experience. Thus, when a ray passes out of air into water, the ratio is as 4 to 3.

out of water into air, as 3 to 4.
air into glass, as 3 to 2.
glass into air, as 2 to 3.
air into diamond, as 5 to 2.
diamond into air, as 2 to 5.

The refraction of light is attributed by sir Isaac Newton to the principle of attraction; and perhaps one of the most satisfactory proofs of this theory is the known fact, that the change in the direction of the ray commences, not when it comes in contact with the refracting medium, but a little before it reaches the surface, and the incurvation augments in proportion as it approaches this medium. Indeed no principle will account for the phenomenon of light passing more easily, that is, more directly, through a dense than through a rare medium, but that of attraction; since it is found by universal experience, that the attraction of all bodies is in proportion to their densities.

In passing from a dense into a rare medium, however, there is a certain degree of obliquity at which the refraction is changed into reflection. In other words, a ray of light will not pass out of a dense into a rare medium, if the angle of incidence exceeds a certain limit, but will be reflected back. Thus a ray of light will not pass out of glass into air, if the angle of incidence exceeds 40° 11′; or out of glass into water, if the angle of incidence exceeds 59° 20′.

As the rays of light, in passing from a dense medium to a rarer, are refracted from the perpendicular, in fact are bent or inclined towards the eye of the spectator, who looks at an object in the denser medium while standing at its side, the reason will be clear why the bottom of a river appears to us nearer than it really is. If the spectator stands on a bank just about the level of the water, it is about one-third deeper than it appears; and why an oar, partly in and partly out of the water, seems broken. Let Q*no* (fig. 26.) represent an oar, the part *n*Q being out of, and the part *no* being in, the water; the rays diverging from *o* will appear to diverge from *b* nearer to the surface of the water, and every point in *no* will be found nearer to the surface than its real place, and the part *no* will appear to make an angle with the part

Qn. On this account also, a fish in the water appears much nearer the surface than it actually is; and a skilful marksman, in shooting at it, will aim considerably below the place which it seems to occupy.

On the same principle a common experiment is explained. Put a shilling into a bason, and walk back from it till the shilling is just obscured by the side of the bason; then by pouring water into the bason, the shilling instantly appears; for by what has been said above, the object, being now in a denser medium, is made to appear nearer to its surface.

As the refraction must in all cases depend on the obliquity of the ray, that part of any body which is most immersed will seem to be most materially altered by the refraction. When, however, the object extends to no great depth in the water, the figure is not materially distorted; but if the object is of a considerable size, or extends to a great depth, those rays which proceed from the more distant extremities come in a more oblique direction on their emergence into the air, and they consequently suffer a greater refraction than the rest. Thus a straight leaden pipe appears near the bottom of a deep water to be curved, and a flat bason seems deeper in the middle than near the sides.

To these laws of refraction is to be attributed the difference between the real and the apparent rising of the sun, moon, and stars, above the horizon. The horizontal refraction is something more than half a degree, whence the sun and moon appear above the horizon when they are entirely below it. From the horizon the refraction continually decreases to the zenith. Refraction is increased by the density of the air, and consequently it is greater in cold countries than in hot; and it is also affected by the degree of cold or heat in the same country.

Parallel rays, if refracted, preserve their parallel direction both in entering and in passing out of a refracting medium, provided the two surfaces of the refracting medium are parallel. The two rays, EA, EA, (fig. 27.) after refraction, while they approach the perpendiculars *pp*, continue parallel as before, the reason of which is evident on the principles already established; for the ray AC, (Pl. XCVII. fig. 3.) on coming in contact with the surface of the refracting medium EF, does not continue its course in the straight line C*b*, but being refracted at the point of contact C, it approaches the perpendicular P*p*, and comes out at *a*.

After coming out of the refracting medium, if we suppose the surface GH parallel to EF, it ought to proceed to B, having deviated from the perpendicular in the same degree in which it approached it on its first refraction; and thus it continues parallel to the line CB, which is that in which it would have proceeded if it had not been intercepted by the medium.

This parallelism cannot subsist if the two surfaces KI, HI, (fig. 4.) are inclined, as in the figure; because the ray entering at *a*, and emerging at *b*, the object A will be seen from the point B at *c*, which is out of its true place.

Converging rays become less convergent in passing from a rare to a denser medium, as from air into water; and on the contrary, their convergence is augmented by passing from a dense to a rarer medium, as from water into air. (See fig. 1.) In the same manner, diverging rays become less divergent in passing out of a rare medium into one which is denser, and their divergence is increased by passing out of a dense into a rarer medium. (See fig. 2.) This fact is a necessary consequence of the general law of refraction: but it will satisfactorily explain why an object under water appears larger to an eye above the surface than it really is, and why all objects appear magnified seen through a mist; for in all these cases, the converging rays, by which we see the extreme points of the object, and which during their passage through the water, &c. were refracted towards the perpendicular, on their emergence into the air are made more suddenly to converge, and consequently the visual angle is rendered more obtuse.

It is evident, that when parallel rays fall upon a spherical surface, that ray only which penetrates to the centre or axis will proceed in a direct course: for all the rest must necessarily make an angle more or less obtuse, in proportion to their distance from the centre; they are therefore rendered convergent or divergent according to the nature of the medium on which they are incident. If they fall on the convex surface of a medium denser than that which they leave, as in passing from air into glass, they will converge, as may be seen in Pl. XCVII. fig. 5. where that phenomenon is represented; for the parallel rays, *hi*, *fg*, (fig. 10.) falling in an oblique direction on the refracting medium terminated by the convex surface E*ig*, they will be refracted, and will each respectively approach the perpendiculars *i*C, or *g*C, and will consequently have a tendency to unite towards the axis AB.

It is however proper to remark, that the point at which they join the axis AB will be distant from the surface of the refracting medium, in proportion as the point on which they fall on the convex surface is distant from that axis; because the more distant that point is, the more oblique is the incidence of the ray. Thus the ray *hi* joins the axis at *k*; but the ray *fg* does not join the axis till it arrives at D.

Rays already convergent, falling on the convex surface of a dense medium, will be acted upon differently according to circumstances.

If their convergence is exactly proportioned to the convexity of the surface, they will not suffer any refraction; (see fig. 6.) because in that case one of the essentials is wanting to refraction, viz. the obliquity of the incidence; and each ray proceeds in a direct line to the centre of that circle, of which the convex surface is an arch or segment.

For instance, the rays *ef* and *dh*, (fig. 11.) which tend to unite at C, the centre of the convex surface, may be considered as perpendicular, being the radi of the circle.

If the rays have a tendency to converge before they reach the centre of the convexity, they will then be rendered less convergent, for instead of converging to a point at *b* (fig. 7.), they will converge at B. The reason of this is evident; for the ray *ih* (fig. 11.) which, if not intercepted, would meet the axis at *k*, nearer the surface of the refracting medium than the centre of convexity C, being refracted towards the perpendicular or radius *d*C, meets the axis only at *o*.

If, on the contrary, the rays have a tendency to converge beyond the centre of the convexity, they will then, by the law of refraction, be rendered still more convergent,

as in fig. 8; where their point of union, if not intercepted, would be c; but where, by the influence of the refraction, they are found to converge at C. For the ray gh, (fig. 11.) the tendency of which is towards l, is refracted towards the perpendicular dC, and joins the axis at p.

If diverging rays fall on the convex surface of a denser medium, they are always rendered less divergent, as in fig. 9.; and they may be rendered parallel, or even convergent, according to the degree of divergence compared with the convexity of the refracting surface, on the principles already explained.

If rays pass from a dense to a rarer medium, the surface of the dense medium being convex, in this case parallel rays become convergent; for the parallel rays de, gi, (fig. 12.) when they reach the convex surface eDi, instead of continuing their direct course, are refracted from the perpendiculars aC, bC, and converge at k.

Converging rays are also rendered more convergent. Thus the rays le, ui, which without any change in the medium, would have proceeded in the direction m and o, in consequence of the refraction which they suffer, and which bends them from the perpendiculars aC, bC, unite at p.

Diverging rays, if they proceed from the point C, the centre of convexity, suffer no refraction; because, for the reasons already assigned, they may be considered as perpendicular to the refracting surface, and consequently they are deficient in one of the causes of refraction, the obliquity of incidence.

If they proceed from a point which is nearer to the surface than the centre of convexity, such as r, they will be refracted from the perpendiculars aC, bC, and will be rendered more divergent towards x and y.

If, on the contrary, the diverging rays come from a point such as q, beyond the centre of convexity, they will be rendered less divergent; for instead of going towards z, they will be refracted from the perpendiculars aC, bC, towards f and h.

When rays pass from a rare into a dense medium, and the surface of the dense medium is concave, then parallel rays are rendered divergent, as in Plate XCVII. fig. 13.; for the parallel rays ab. de, (fig. 17.) are refracted towards the perpendiculars fC and gC, and are consequently divergent.

Converging rays falling on the same concave surface will be rendered less convergent, as in fig. 14. For the rays ab, de, (fig. 18.) which would have converged at O if their progress had not been intercepted, will be refracted towards the perpendiculars fC and gC, and will unite only at i. If the convergence was less, they might by the refraction be rendered parallel, or even divergent.

Diverging rays proceeding from the centre of concavity will not suffer any refraction, for the reasons already assigned.

If, however, divering rays proceed from any point nearer the refracting surface than the centre of concavity, they will be rendered less divergent, as in fig. 15. For the two diverging rays kb and ke (fig. 19.), instead of proceeding to d and h, are refracted towards the perpendiculars fC and gC.

If, on the contrary, which is the most general case, the diverging rays proceed from a point more distant from the surface than the centre of concavity, their divergence will be increased, as in fig. 16. For the diverging rays lb and le (fig. 19.), which tend towards m and n, are refracted towards the perpendiculars fC and gC, and become more divergent than they would otherwise have been.

When rays pass from a dense into a rarer medium, and the dense medium is terminated by a concave surface, then

Parallel rays become divergent; for the parallel rays de, gi, (fig. 20.) when they reach the concave surface eDi, instead of continuing their course in the direct line towards f and h, proceed towards m and p, being refracted from the perpendiculars Ca, Cb, and are consequently divergent.

Converging rays, if their point of convergence is precisely at C, the centre of the concavity eDi, will not suffer any refraction, because they are perpendiculars, as already explained, therefore have no obliquity of incidence. If, on the other hand, the rays tend to a point, such as n, nearer to the surface than the centre of the concavity C, then they are rendered more convergent; for the rays qe, ri, which naturally tend to that point, are refracted from the perpendiculars Ce, Ci, and converge at o, nearer the concave surface.

Lastly, if the converging rays tend to a point l, which is beyond the centre C, they are rendered less convergent. For the rays se, ti, which would naturally unite at that point, are refracted from the perpendiculars Ce, Ci, and unite at k, which is more distant still.

Diverging rays in the same circumstances are rendered more divergent. For the rays Ee, Ei, diverging from the point E, instead of proceeding towards a and x, are refracted from the perpendiculars, and are directed towards y and z.

From the property which all spherical convex surfaces have, of rendering parallel rays passing out of a rarer medium convergent, glasses made in this form are very commonly used as burning-glasses; and as the sun's rays, proceeding from so vast a distance, may be considered as parallel, the focus of parallel rays will of course be their burning-point.

A lens is a transparent body of a different density from the surrounding medium, and terminated by two surfaces, either both spherical, or the one plane and the other spherical, whether convex or concave. They are therefore generally distinguished by their forms, and are called plano-convex or plano-concave, or double convex or double concave: a lens which has one side convex and the other concave, is called a meniscus, or concave-convex lens. See Plate XCVII. fig. 21.

It is evident, that in lenses there may be almost an infinite variety with respect to the degree of convexity or concavity; for every convex surface is to be considered as the segment of a circle, the diameter and radius of which may vary to almost an infinite extent. Hence, when opticians speak of the length of the radius as applied to a lens, as for instance, when they say its radius is 5 or 6 inches, they mean that the convex surface of the glass is the part of a circle, the radius of which, or half the diameter, is 5 or 6 inches.

The axis of a lens is a straight line drawn through the centre of its spherical surface; and as the spherical sides of every lens are arches of circles, the axis of the

lens would pass exactly through the centre of that circle, of which its sides are arches or segments.

From what has been already stated, it is obvious that the certain effect of a convex lens must be to render parallel rays convergent; to augment the convergence of converging rays; to diminish in like manner the divergence of diverging rays, and in some cases to make them parallel or even convergent, according to the degree of divergence compared with the convexity of the lens. In what is called a double-convex lens, this effect will be increased in a duplicate proportion, since both surfaces will act in the same manner upon the rays; and since it has been proved, that parallel or convergent rays have their convergence equally augmented by being incident on the convex surface of a dense, or the concave surface of a rare medium. These glasses then must necessarily have the effect of magnifying glasses. since by the convergence of the rays the visual angle is rendered more obtuse, and consequently the image which is depicted on the retina must be proportionably larger.

The focus of those rays which come in a parallel direction to the glass, is called the focus of parallel rays, or principal focus. In a plano-convex glass this focus is at the length of the diameter of that circle, of which the convex surface is a segment; and in a double-convex lens, or one which is convex on both sides, the focus is as the distance of the radius, or half the diameter, of the circle of which the lens is a segment. This focus therefore is easily found upon mathematical principles. It may also be found, though not with equal exactness, by holding a sheet of paper before the glass when exposed to the rays of the sun, and observing the distance of the paper from the glass when the luminous spot on the paper is very small, and when it begins to burn; or when the focal length does not exceed three feet, the focus may be found by holding the lens at such a distance from the wall opposite a window-sash, that the image of the sash may appear distinct upon the wall.

From this property in convex lenses, of rendering all rays in some degree convergent which fall upon their surfaces, it is evident that in all such cases there must be a point, which in general is at the focus, where pencils of rays proceeding from the extreme point of any object must first unite and then cross each other; and consequently an inverted image of the object will be exhibited at any distance beyond that point. This may be elucidated by a very easy experiment, viz. by holding a common reading or magnifying glass between a candle and a sheet of paper suspended on the wall, at a proper distance, when the image of the candle will appear on the paper inverted: and the reason of this is extremely clear; for it is evident that the upper pencils after refraction, are those which proceeded from the under part of the luminous body, and the under rays are those which come from its top. The position is therefore only inverted, and the images remain unimpaired.

From the same property, convex lenses will cause many rays to enter the eye which would otherwise have been scattered or dispersed, and therefore objects seen through them appear clearer and more splendid that when viewed by the naked eye. If, however, the glass is very thick (as in high magnifiers), some of the rays which enter it will be reflected or sent back, and consequently the brilliancy of the image will suffer some diminution.

A large object seen through a lens which is very convex will appear deformed; and this proceeds from the refraction not being equal at all points in such cases. The same cause operates also to render some parts of the image indistinct, while others are distinct and clear. Thus the extremities of the image seen through a lens of a very short focus are commonly confused and indistinct, because the refraction at the edges of the lens does not agree with that of the middle parts. The modes adopted for remedying these defects in optical glasses, will be hereafter explained.

The effects of a concave lens are directly opposite to those of the convex lens. In other words, by such a glass, parallel rays are rendered divergent, converging rays have their convergence diminished, and diverging rays have their divergence augmented, in proportion to the concavity of the lens. These glasses then exhibit objects smaller than they really are; for by causing the rays to diverge, or more properly by diminishing the convergence of the rays proceeding from the extreme points of the object, the visual angle is rendered more acute, and the image painted on the retina is smaller than it would have been had these rays not been intercepted in their natural progress; and by the divergence of the rays the object is represented with less clearness than it would otherwise have had, since from this cause a less quantity of light enters the pupil of the eye. All concave lenses have a negative or virtual focus, which is a point corresponding with the divergence of parallel rays incident on the surface of the lens.

Light is, however, not so simple a substance as may be supposed upon superficially considering its general effects; it is indeed found to consist of particles which are differently refrangible, that is, some of them may be refracted more than others in passing through certain mediums, whence they are supposed by philosophers to be different in size. The common optical intrument called a prism, is a triangular piece of glass, through which if a pencil or collection of rays is made to pass, it is found that the rays do not proceed parallel to each other on their emergence, but produce on an opposite wall, or any plane surface that receives them, an oblong spectrum, which is variously coloured, and it consequently follows that some of the rays or particles are more refrangible than others.

The spectrum thus formed is, perhaps, the most beautiful object which any of the experiments of philosophy presents to our view. The lower part, which consists of the least refrangible rays, is of a lively red; which, higher up, by insensible gradations, becomes an orange; the orange, in the same manner, is succeeded by a yellow; the yellow, by a green; the green, by a blue; after which follows a deep blue or indigo; and lastly, a faint violet.

Of vision. There is not any part of the animal frame which displays in a more satisfactory manner to our reason, the wisdom and design of our Creator, than the eye. Its anatomical structure is however explained under the articles Anatomy and Physiology. It is only necessary at present to consider it as an optical instrument. The external coat or case, which forms the globe of the eye, is at the back part strong and opake: the fore part

is thin and transparent, so as to admit readily the rays of light; and it is therefore called the cornea, from its resemblance to polished horn. It incloses three pellucid matters called the humours, which are of different densities. That in the anterior part, immediately under the cornea, is called the aqueous humour; that immediately behind is the crystalline humour, which is a double-convex lens of great refracting power, and the rest of the eye is filled with a jelly-like substance called the vitreous humour. The iris, which is the coloured part of the eye, is an opaque membrane which is perforated by a small hole, the pupil, through which the rays of light must pass to the crystalline humour. The optic nerve enters at the under part, and is spread all over the inferior surface, at the back of the eye, in the form of a fine network, and therefore is called the retina. The student of optics will see from this, that the eye is altogether calculated to act as a convex lens of strong refractive powers.

It has already been explained, that from every luminous point of a visible object, cones or pencils of light are emitted or reflected in every direction; but to produce vision, it is necessary that they should be concentrated or converged to such a point as to make a forcible impression on the retina. Thus from the luminous body A, Plate XCVII. fig. 22. the rays *r*, *r*, *r*, are sent in various directions. Those which fall upon the transparent cornea CC, are there refracted in such a manner as to enter the pupil at *p*, and in passing the chrystalline lens or humour they suffer a second refraction, and are converged to a point or focus at the point *a* on the retina. Now it is evident, that if the rays could have passed the humours of the eye in their natural direction, that is, in the direction of the cone or pyramid CAC, they would have made upon the retina a very extensive but feeble impression, such as we know by experience could not produce distinct vision; to obviate this it is appointed by the all-wise Author of our existence, that by the force of the refraction which they suffer in the eye, they should form another cone opposed to the first at its base, and the apex of which is at *a*, and thus an impression sufficiently forcible to produce distinct vision is made on the retina.

In the preceding instance, the luminous body A was considered as a point; and what has been said of it will apply to every point of a visible object, which is capable of transmitting or reflecting to the eye a pencil or collection of rays. Thus we may easily suppose that from every part of the arrow O A B. (fig. 23.) cones or pencils of light may be transmitted; these, like all pencils or collections of rays, coming from a point, will diverge, and will fall upon the eye in some degree divergent, or in the form of cones or pyramids.

The pencil of rays OEIF will then paint the extremity O in the point I; the pencil BFME will also paint the extremity B in the point M; and since all the points between O and B are represented between I and M, of course IM will be the image of OB. Hence it is evident, that by means of this refraction there are certain points at which the rays of light, after passing the pupil, cross each other, and the image which is formed on the retina is consequently inverted.

Artificial eyes are sold by the opticians, in which all the humours are made of different kinds of glass, and may be separated at pleasure. At the back part, where the retina is supposed in the natural eye to receive the converged rays, is placed a piece of ground glass, where the image from the opposed object is rendered in an inverted position, as in a camera obscura. The same effect may be produced with a natural eye, and the nature of vision may be thus experimentally demonstrated: if a bullock's eye is taken fresh, the posterior coats dexterously removed even to the vitreous humour, and if a piece of white paper is then placed at the part, the image of any bright object which is placed before the eye will be seen distinctly painted on the paper, but in an inverted position.

If the humours of the eye, through age or weakness, have shrunk or decayed, the cornea will then be too flat; and the rays, not being sufficiently bent or refracted, arrive at the retina before they are united in a focus, and would meet, if not intercepted, in some place behind it, as in Plate XCVII. fig. 25. They therefore do not make an impression sufficiently correct and forcible, but form an indistinct picture on the bottom of the eye, and exhibit the object in a confused and imperfect manner. This defect of the eye is therefore remedied by a double-convex lens, such as the common spectacle glasses, which, by causing the rays to converge sooner than they otherwise would, afford that aid to this defect of nature which the circumstances of the case may require; the convexity of the glass being always proportioned, by one who is capable of directing in the choice of spectacles, to the deficiency in vision.

If, on the contrary, the cornea is too convex, the pencils of rays will unite in their foci before their arrival at the retina, as in fig. 26, and the image will also be indistinct. This defect is to be remedied by concave glasses, which cause the rays to diverge; and consequently, by being properly adapted to the case, will enable the eye to form the image in its proper place.

The rays of light being emitted or reflected from a visible object in all directions, it must be plain that some of them from every part of it must reach the eye. Thus the object AB (Plate XCVII. fig. 28) is visible to an eye in any part where the rays A*a*, A*b*, A*c*, A*d*, A*e*, B*a*, B*b*, B*c*, B*d*, B*e*, C*a*, C*b*, C*c*, C*d*, and C*e*, can come. But though rays are reflected from every point of the object to every part of the circumambient space, yet it is evident that only those rays which pass through the pupil of the eye can affect the sense; and those rays also give the ideas of colour, according to the properties of those bodies which transmit or reflect them.

As the direction in which the extreme pencils of light cross each other in the eye, bears a due proportion to the angle in which they are transmitted from the object to the eye, it is evident that the image formed upon the retina will be proportioned to the apparent magnitude; and thus we have our first ideas of the size and distance of bodies, which, however, in many cases are corrected by experience. The nearer any object is to the eye, the larger is the angle by which it will appear in the eye, and therefore the greater will be the seeming magnitude of that body. In Plate XCVII. fig. 24. let AB be an object viewed directly by the eye QR. From each extremity draw the lines AN and BM, intersecting each other in the crystalline humour at I. Then draw the line IK in the

direction in which the eye is supposed to look at the object. The angle AIB is then the optical or visual angle; and the line IK is called the optical axis, because it is the axis of the lens or crystalline humour continued to the object.

The apparent magnitude of objects, then, depending thus on the angle under which they are seen, will evidently vary according to their distances. Thus different objects, as AB, CD, EF, the real magnitudes of which are very unequal, may be situated at such distances from the eye as to have their apparent magnitudes all equal; for if they are situated at such distances that the rays AN, BM, shall touch the extremities of each, they will then appear all under the same optical angle, and the diameter MN of each image on the retina will consequently be equal.

In the same manner objects of equal magnitude, situated at unequal distances, will appear unequal. For let AB and GH, two objects of equal size, be placed before the eye at different distances, IK and IS; draw the lines GP and HO, crossing each other in I; then OP, the image formed by the object GH on the retina, is evidently of a greater diameter than the image MN, which represents the object AB; in other words, the object GH will appear as large as an object of the diameter TV, situated at the same place as the object AB.

To render the subject still clearer, suppose the object HK (see Plate XCVII. fig. 27) to be at a hundred yards distance, it will form an angle in the eye at A. At two hundred yards distance the angle it makes will be half as large in the eye at B. Thus to whatever moderate distance the object is removed, the angle it forms in the eye will be proportionably less, and therefore the object will be diminished in the same proportion.

Hence it follows, that objects situated at different distances, whose apparent magnitudes are equal, are to each other as their distances from the eye; and by the same rule, equal objects situated directly before the eye, have their apparent magnitudes in a reciprocal proportion to their distances.

This last proposition must, however, be received with some allowance; for it is only applicable to very distant objects, and to those where the sense is not corrected by the judgment. For if the objects are near, we do not judge of their magnitude according to the visual angle. Thus, if a man of six feet high is seen at the distance of six feet under the very same angle as a dwarf of only two feet hight at the distance of two feet, still the dwarf will not appear as large as the man, because the sense is corrected by the judgment.

In most cases, however, where the distance is considerable, the rule will be found accurate; and as it has its foundation in nature, most of the phenomena of vision will be explained by having recourse to the principles here laid down. If the eye is placed above a horizontal plane, the different parts of this plane will appear elevated in proportion to their distance, till at length they will appear upon a level with it. For in proportion as the different parts are more distant, the rays which proceed from them form angles with the optical axis IK (Plate XCVII. fig. 24) more and more acute, and at length become almost parallel. This is the reason why, if we stand on the sea-shore, those parts of the ocean which are at a great distance appear elevated: for the globular form of the earth is not perceptible to the eye; and if it was, the apparent elevation of the sea is far greater than the arch which a segment of the globe would form within any distance that our eyes are capable of reaching.

For the same reason, if a number of objects are placed on the same plane and at the same height below the eye, the more distant will appear taller than the others; and if the same objects are placed on a similar plane above the eye, the more distant will appear the lowest.

The distant parts of a long wall, for the same reason, appear to a person who stands near one end to curve, or incline towards him. In the same manner the high wall of a lofty tower seems to a spectator, placed directly under it, to bend over him, and threaten him with instant destruction. If any person inclined to make the experiment will lie down on his back in a situation of this description, at the distance of five or six feet from the wall of which he contemplates the tremendous height, he will immediately be made sensible of the phenomenon.

If the distance between two objects forms an insensible angle, the objects, though in reality at some distance from each other, will appear contiguous. This is assigned by some astronomers as the reason why the ring or belt of Saturn appears as one mass of light, while they contend that it is formed from a number of little stars or satellites ranged within a certain distance of each other.

If the eye is carried along, as in a boat, without being sensible of its own motion, the objects which are stationary on each side will appear to move in a contrary direction. Thus we attribute to the sun and the other heavenly bodies a diurnal motion, which only affects the earth which we inhabit.

If two or three objects at a considerable distance, and on which the eye of the spectator is fixed, move with equal velocity past a third object which is at rest, the moving objects will appear to be actually at rest, and that which is really stationary will appear in motion. Thus the clouds which pass over the face of the moon appear at rest, while the moon itself appears to proceed rapidly along in an opposite direction. This happens, because the eye which is fixed upon the clouds follows their motion mechanically, and therefore the moon appears to move and not the clouds; as in the boat we do not perceive its motion, but conceive the banks are retiring behind us.

If the centre of the pupil, that is, the optic axis, is directed along the surface of any slender object in a perfectly right line, this line will appear only a point, because, in fact, the extremities only are visible.

An extended and distant arch, viewed by an eye which is exactly in the same line, will appear as a plane surface; because all the parts appearing equally distant, the curvature will not be perceived.

If a circle is viewed obliquely it will appear an oval, because the diameter which is perpendicular to the eye is shortened; in other words, the rays which proceed from the extremities form an angle so much the more acute as the obliquity is greater; on the contrary, the diameter which is parallel to the eye is apparently extended.

Such are the general principles upon which vision is performed; but the sense of sight is limited not only with respect to distant objects, but with respect to those which

are near. Every person will easily perceive that if a book, or any other object, is held too close to the eye, the letters or the object will appear very indistinct and confused. This distance varies with respect to different eyes. Very near-sighted persons can see at the distance of one or two inches; but where the eye is in a sound state, the point of distinct vision varies from six to ten inches, or eight inches as a medium.

To understand the reason of this, it is necessary to remember that objects are made visible by cones of diverging rays proceeding from every luminous point of an object; but to have the object clearly painted on the retina, the rays must not enter the pupil of the eye too divergent. Indeed they ought to come in almost a parallel direction, more in the form of a cylinder than a cone, otherwise the humours of the eye will not make them converge at the proper points on the retina. Thus, let us suppose CD (Plate XCVIII. fig. 22) to be the diameter of the pupil of the eye; O is then a luminous point of any object situated at the distance of about six inches, and OC and OD are divergent rays proceeding from this point. Let AC and BD than be parallel rays. It will then be evident that the divergency of the rays OC and OD is so very small, that they are almost parallel when they arrive at the pupil; and consequently the eye will be able to converge them in such a degree as to produce distinct vision.

If, on the contrary, the point O was nearer to the pupil, or if the pupil was larger, they would fall more diverging upon the eye, and the image of the object would be formed at a point behind the retina, so as to be very imperfect and confused. Hence we may easily perceive the use of a single lens of a short focus, or high magnifying power, such as is employed in the single miscroscope. It renders these divergent rays less divergent; and consequently assists the eye in making them converge to that point which is necessary to distinct vision.

From the principles laid down it may easily be understood why very minute objects are imperceptible to the naked eye. If those objects could, consistently with distinct vision, be brought near to the eye, they would be perceived as well as by the aid of a microscope: hence some very near-sighted persons may be said to have microscopic eyes; but at six or eight inches (the limit of distinct vision) these objects subtend too small an angle to be perceptible. Opticians say that the eye is not capable of perceiving any object which subtends an angle of less than half a minute of a degree. The image on the retina is in this case less than the $\frac{1}{7200}$ part of an inch, and the object itself at six inches distance less than the $\frac{1}{1200}$ part of an inch broad. All smaller objects are invisible.

All very distant objects, upon the same principles, appear indistinct; for their images on the retina are so extremely small, that the distinction of parts is not perceptible. Thus if a man, of six feet stature, is viewed at the distance of a mile; his image on the retina will not be more than the thousandth part of an inch in length. We cannot be surprised, therefore, if the eye can discern nothing of his features, or the minuter parts of his body.

Distant objects, however, appear not only indistinct but obscure; and this last effect is from a deficiency of light, very many of the rays being intercepted in their passage through the air. Hence the difference in the appearance of such objects in a dark and cloudy day, when the air is impregnated with vapours, from that which they assume when the sun shines full and strong upon them.

With a single glass the defects in sight, with respect to many objects, either too near, or at too great a distance, for the persons labouring under them, are remedied; but there are cases where the object is so far distant, or so minute, that, though its outline may reach the eye, its parts must still, even with the aid of a single lens, be indistinctly perceived. The art of man has discovered a remedy, in a great degree, for this imperfection; and by means of a combination of glasses has opened a wide field for his researches into the wonders of nature: he can now trace the limbs of an insect invisible to the naked eye; or he can make the celestial objects appear to him as if their distance had been on a sudden diminished by many millions of miles.

Optical instruments.—From what has been stated concerning vision, the principle of the single microscope will be easily understood. Since the eye cannot have a distinct perception of any object at a nearer distance than six or eight inches, and since there are many objects which at that distance must be wholly imperceptible, or at best appear as points, an instrument which can render them visible, is a very desirable attainment.

It has been sufficiently explained that objects appear larger or smaller in proportion to the angle under which they are seen. Since therefore the rays by which small objects are rendered visible by the microscope, must come from the extreme points of that object, it is manifest that though the apparent magnitude is increased by the interposition of the lens, its real magnitude remains the same. The lens enables us to view it at a shorter distance; it will therefore appear exactly as much larger in diameter through the lens, as its distance from the glass is less than the nearest distance of distinct vision with the naked eye.

Let A (Plate XCVIII. fig. 1) be then a point of an object not visible to the eye at a less distance than AB, because the rays are too divergent for distinct vision. Now if the same object is placed in the focus C of the lens D, the rays which proceed from it will be rendered parallel by passing the lens; and therefore the object is rendered distinctly visible to the eye at E. It will then of course appear as much larger through the lens than to the naked eye, as CD is less than AB.

If the object AB is in the one focus of the lens DE, and the eye in the other focus F (fig. 2), as much of the object will be visible as is equal to the diameter of the lens; for the rays AD and BE proceed through the extremities of the lens, and are united at the focus F, and render the extreme parts of the object visible. Hence a maxim in optics, "that when an object is placed in one focus of a lens, and the eye in the other, the object appears just twice as large as it would to the naked eye, whatever the size of the lens:" for the lines FD and FE, if protracted to the distance of A and B, would form an image exactly twice as large. "If, on the other hand, the eye is nearer to the lens than the focus, it will see the object still larger; and if it is farther than the focus it will not see it so large: and in all cases the visible part of the object will be to the lens, as the focal distance of the lens is to the distance of the eye.

From what has been said, the reason will be very plain

why the magnitude of objects seen through a double-convex lens, that is, a single microscope, will be in the proportion which the focus of the lens bears to the limits of distinct vision. Thus, suppose AB, fig. 1, to be that distance, or about six inches, so that the eye B can but just perceive the object A, and let the focal distance of the less D be one-half of an inch; then since CD is but one-twelfth of AB, the length of the object at C will appear twelve times as large as at A, and its surface will appear magnified 144 times.

The most powerful single microscopes are very small globules of glass, which any curious person may make for himself by melting the ends of fine threads of glass in the flame of a candle; or by taking a little fine powdered glass on the point of a very small needle, and melting it into a globule in that way. It was with such microscopes as these that Lewenhoeck made all his wonderful discoveries, most of which are deposited in the British Museum.

The double or compound microscope differs from the preceding in this respect, that it consists of at least two lenses, by one of which an image is formed within the tube of the microscope; and this image is viewed through the eye-glass, instead of the object itself as in the single microscope. In this respect the principle is analogous to that of the telescope, only that, as the latter is intended to view distant objects, the object-lens is of a long focus, and consequently of a moderate magnifying power, and the eye-glass of a short focus, which magnifies considerably the image made by the object lens. Whereas the microscope being intended only for minute objects, the object-lens is consequently of a short focus, and the eye-glass in this case is not of so high a magnifying power.

A single figure will serve to explain the principles on which all these instruments are constructed. Suppose therefore LN (Plate XCVIII. fig. 3) to be the object-lens, and FG to be the eye-glass. The object OB is placed a little beyond the principal focus of LN. The cones or pencils of rays then proceeding from the different points of the object, are by the lens made to converge to their respective foci, and form an inverted image of the object at PQ. This image is seen through the eye-glass FG, and the rays of each pencil will proceed in a parallel direction to the pupil of the eye.

The compound microscope was thus originally constructed of two glasses, but it was found that what is called the field of view was too confined in instruments of this construction. For the pencil of rays which emanates from the point O of the object, and is converged by the lens to D, would proceed afterwards diverging towards H, and therefore would never arrive at the lens FG, nor enter the eye at E; but the pencils which proceed from *o* and *b* will be converged to the lens FG, and sent to the eye at E in a parallel direction. Hence if the object is large, a very small part of it will be visible, because several pencils will fall without the eye-glass FG, and the field of view will consequently be very limited.

To remedy this inconvenience, a broad lens DE is interposed, either of a plano-convex, or of a double-convex, form. By this, it will be perceived, the pencils which would have proceeded towards H and *I*, will be refracted to the eye-glass, and the figure will be completely formed as in the plate. This glass is called by opticians the body-glass, because it is situated in the body of the microscope. Some artists now make these instruments with two eye-glasses, made rather thin, which in some degree corrects what is called the aberration, or dispersion of the rays. In all these microscopes the object is seen in an inverted position; but this is of little importance with regard to small insects and other minute bodies.

The solar microscope is a kind of camera obscura, which, in a darkened chamber, throws the image on a wall or screen. It consists of two lenses fixed opposite a hole in a board or window-shutter; one, which condenses the light of the sun upon the object (which is placed between them), and the other which forms the image. There is also a plain reflector placed without, moved by a wheel and pinion, which may be so regulated as to throw the sun's rays upon the outer lens. The reader may form some idea of this by inspecting the Plate XCVIII. fig. 12, of the camera obscura, only supposing the figures on the wall to be a microscopic object magnified by the lens. Mr. Adams's most ingenious invention, the lucernal microscope, is also to be considered as a kind of camera obscura; only the light in this latter case proceeds from a lamp, instead of from the sun, which renders it convenient to be used at all times. But for a description of this elegant and most amusing instrument, we must refer to his Microscopical Essays.

From what has been said on the nature of the compound microscope, the principle of the telescope may be easily understood. Telescopes are, however, of two kinds: the one depending on the principle of refraction, and called the dioptric telescope; the other on the principle of reflection, and therefore termed the reflecting telescope.

The parts essential to a dioptric telescope are, the two lenses AD and EY (Plate XCVIII. fig. 4). As in the compound microscope, AD is the object-glass, and EY is the eye-glass; and these glasses are so combined in the tube, that the focus F of the one is exactly coincident with the focus of the other.

Let OB then represent a very distant object, from every point of which pencils of rays will proceed so little diverging to the object-lens AD, that they may be considered as nearly parallel; IM will then be the image which would be formed on a screen by the action of the lens AD. For supposing OA and BD two pencils of rays proceeding from the extreme points of the object, they will unite in the focal point F, and intersect each other. But the point F is also the focus of the eye-glass EY; and therefore the pencil of rays, instead of going on to diverge, will pass through it in nearly a parallel direction, so as to cause distinct vision.

It is then plain that, as in the compound microscope, it is the image which is here contemplated; and this will account for the common sensation when people say the object is brought nearer by a telescope. For the rays, which after crossing proceed in a divergent state, fall upon the lens EY, as if they proceeded from a real object situated at F. All that is effected by a telescope then is, to form such an image of a distant object, by means of the object-lens, and then to give the eye such

assistance as is necessary for viewing that image as near as possible; so that the angle it shall subtend at the eye shall be very large compared with the angle which the object itself would subtend in the same situation. This is effected by means of the eye-glass, which refracts the pencils of rays, so that they may be brought to their several foci by the humours of the eye, as has been described.

To explain clearly, however, the reason why it appears magnified, we must again have recourse to the figure. OB being at a great distance, the length of the telescope is inconsiderable with respect to it. Supposing, therefore, the eye viewed it from the centre of the object-glass C, it would see it under the angle OCB: let OC and BC then be produced to the focus of the glass, they will then limit the image IM formed in the focus. If then two parallel rays are supposed to proceed to the eye-glass EY, they will be converged to its focus H, and the eye will see the image under the angle EHY. The apparent magnitude of the object seen by the naked eye is, therefore, to that of the image which is seen through the telescope, as the magnitude of the angle OCB, or ICM, to that of EHY, or IGM. Now the angle IGM is to ICM as CF to FG; that is, as the focal length of the object-glass to that of the eye-glass.

The magnifying power of these glasses may be augmented to a considerable degree, because the focal length of the object-glass, with respect to that of the eye-glass, may be greatly increased. This however would require a tube of immense length; because an eye-glass of a very short focus would cause such a dispersion of the rays of light, particularly towards the edges of the glass, that the view would be intercepted by the prismatic colours.

Another manifest defect in these telescopes is, that the image appears inverted: this, however, is of no consequence with respect to the heavenly bodies; and on this account it is still used as an astronomical telescope. One of almost a similar construction is also used on board of ships as a night-glass, to discover rocks in the ocean, or an enemy's fleet. Notwithstanding the inconvenience of exhibiting the objects inverted, more glasses than two cannot be employed from the paucity of light; and habit soon enables the persons who use them to discern objects with tolerable distinctness.

Galileo, who had heard of the invention of telescopes, but had not seen one, constructed a telescope upon theoretical principles, and adopted a concave lens as an eye-glass, but whether with a view of obviating the disagreeable effect produced by the inversion of the image or not is uncertain. This effect is however produced by the Galilean telescope, the construction of which is as follows: Let AB, fig. 5, be a very distant object, from every point of which pencils of rays proceed to the convex lens DE, and are refracted towards their foci at FSG. But a concave lens HI, the virtual focus of which is at FG, being interposed, the rays are not suffered to converge to that point; but being made less convergent, as is the effect of these glasses, enter the pupil almost parallel, and are converged by the humours of the eye to their proper foci on the retina at PQR: and the object will appear erect, because the pencils of rays cross each other only once, as in natural vision. Objects are seen very distinct through this telescope; but the field of view is so small, that its use is almost exclusively confined to the common opera-glasses. For if the focus of the eye-glass is short, the pencils of rays are rendered so divergent, that but a few of them can enter the pupil.

It was necessary then, to render the dioptric telescope useful for terrestrial purposes, to cause the image to be seen in an erect position. This was effected by the addition of two other convex lenses; of this Kepler suggested the idea, though it was not reduced to practice till thirty years after his time. The principle on which this telescope is constructed will be easily understood from what has been premised, and by inspecting the Plate, fig. 6. It will be seen there, that to the common astronomical telescope, there are added two other eye-glasses of the same focus as the first, LM and QR; and the first of these is placed at twice its focal distance from HI. After the rays therefore have passed the first eye-glass HI, instead of being received by the eye, as in the former case of the astronomical telescope, they pass on; the rays which constitute each pencil being rendered parallel: and in this state the respective pencils cross each other in the common focus, and the rays are received in this parallel state by the second eye-glass LM. The rays then constituting the respective pencils converge to their foci at NO, where a second image is formed, but inverted with respect to the former image EF. This then is the image which is viewed through the third eye-glass QR; and being in the same position as the object itself, is painted on the retina at XZY, and causes the object to be seen erect, as if no glasses had been interposed. The apparent magnitude of the object is not changed by these glasses; and depends, as before, on the focal lengths of the first object-glass and the lens nearest to it. The brilliancy of the object, however, will be diminished, since several rays will be lost in their passage through the two additional glasses. In placing the glasses in this telescope, care must be taken that the axes of the lenses coincide, or, as it is evident from our principles, indistinct vision only will be produced.

The brightness of the appearance through any of these telescopes or microscopes, depends chiefly on the aperture of the object-glass. For if the whole of that glass was covered except a small aperture in the middle, the magnitude of the image would not be altered; but fewer rays of every pencil being admitted, the object would appear obscure.

In few words, the apparent distinctness or confusion of any object, viewed through glasses, depends on the mutual inclination of the rays in any one pencil to each other, when they fall on the eye; the apparent magnitude depends upon the inclination of the rays of different pencils to each other; the apparent situation depends upon the real situation of the extreme pencils; and the apparent brightness or obscurity depends on the quantity of rays in each pencil.

As the magnifying power of all dioptric telescopes depends on the proportion which the focal length of the eye-glass bears to that of the object-glass; and as an eye-glass of very high magnifying powers could not be used on account of the aberration or dispersion of the rays, from the unequal thickness of the glass; various contri-

vances were invented for the sake of employing object-glasses of a very long focus. Wooden tubes of a very great length were found unmanageable. At length the famous Huygens invented a mode of dispensing with the tube. He attached the object-glass to a high pole, with a piece of mechanism which enabled him to raise or lower it at pleasure; and he made the eye-glass correspond to it by a silk cord, which he held tight in his hand. This method is, we believe, still in use on the continent for celestial objects, and distinguished by the name of the aerial telescope.

These inventions were however all rendered nugatory by the discovery of the reflecting telescope. For a dioptric or refracting telescope, even of one thousand feet focus, if it could be used, could not be made to magnify with distinctness above one thousand times; whereas a reflecting telescope of the length of eight or nine feet will magnify with distinctness 1200 times.

The well-known property in concave speculums, of causing the pencils of rays to converge to their foci, and there forming an image of any object that may be opposed to them, gave rise to the reflecting telescope. In this the effect is precisely the same as that produced by the dioptric telescope; only that in the one case it is produced by reflected, and in the other by refracted, light. Reflecting telescopes are made in various forms; and those principally iu use in this country are distinguished by the names of their respective inventors, and are called the Newtonian, Gregorian, and Herschelian telescopes. The reflecting telescope on the Gregorian principle, which is the most common, as it is found to be the most convenient, is constructed in the following manner:

At the bottom of the great tube (Plate XCVIII. fig. 7) TTTT, is placed a large concave mirror DUVF, whose principal focus is at *m*: and in the middle of this mirror is a round hole P, opposite to which is placed the small mirror L, concave towards the great one; and so fixed to a strong wire M, that it may be removed farther from the great mirror, or nearer to it, by means of a long screw in the inside of the tube, keeping its axis still in the same line P*mn* with that of the great one. Now, since in viewing a very remote object, we can scarcely see a point of it but what is, at least, as broad as the great mirror, we may consider the rays of each pencil, which flow from every point of the object, to be parallel to each other, and to cover the whole reflecting surface DUVF. But to avoid confusion in the figure, we shall only draw two rays of a pencil flowing from each extremity of the object into the great tube; and trace their progress through all their reflections and refractions to the eye *f* at the end of the small tube *tt*, which is joined to the great one.

Let us then suppose the object AB to be at such a distance, that the rays C may flow from its upper extremity A, and the rays E from its lower extremity B; then the rays C falling parallel upon the great mirror at D, will be thence reflected converging in the direction DG; and by crossing at I in the principal focus in the mirror, they will form the lower extremity of the inverted image IK, similar to the upper extremity A of the object AB; and passing on to the concave mirror L (whose focus is at *n*), they will fall upon it at *g*, and be thence reflected, converging in the direction *g*N, because *gm* is longer than *gn*; and passing through the hole P in the large mirror, they would meet somewhere about *r*, and form the upper extremity *a* of the erect image *ab*, similar to the upper extremity A of the object AB. But by passing through the plano-convex glass R in their way, they form that extremity of the image at *a*. In the same manner the rays E, which come from the bottom of the object AB, and fall parallel upon the great mirror at F, are thence reflected, converging to its focus; where they form the upper extremity I of the inverted image IK, similar to the lower extremity B of the object AB: and thence passing on to the small mirror L, and falling upon it at *h*, they are thence reflected in the converging state *h*O; and going on through the hole P of the great mirror, they would meet somewhere about *q*, and form there the lower extremity *b* of the erect image *ab*, similar to the lower extremity B of the object AB; but by passing through the convex glass R in their way, they meet and cross sooner, as at *b*, where that point of the erect image is formed. The like being understood of all those rays which flow from the intermediate points of the object between A and B, and enter the tube TT, all the intermediate points of the image between *a* and *b* will be formed; and the rays passing on from the image through the eye-glass S, and through a small hole *e* in the end of the lesser tube *tt*, they enter the eye *f*, which sees the image *ab* (by means of the eye-glass) under the large angle *ced*, and magnified in length under that angle from *c* to *d*.

In the best reflecting telescopes, the focus of the small mirror is never coincident with the focus *m* of the great one, where the first image IK is formed, but a little beyond it (with respect to the eye) as at *n*; the consequence of which is, that the rays of the pencils will not be parallel after reflection from the small mirror, but converge so as to meet in points about *q*, *e*, *r*; where they would form a larger upright image than *ab*, if the glass R was not in their way, and this image might be viewed by means of a single eye-glass properly placed between the image and the eye: but then the field of view would be less, and consequently not so pleasant; for that reason the glass R is still retained, to enlarge the scope or area of the field.

To find the magnifying power of this telescope, multiply the focal distance of the great mirror by the distance of the small mirror from the image next the eye, and multiply the focal distance of the small mirror by the focal distance of the eye-glass: then divide the product of the former multiplication by that of the latter, and the quotient will express the magnifying power. The difference between the Newtonian and Gregorian telescope is, that in the former the spectator looks in at the side through an aperture upon a plane mirror, by which the rays reflected from the concave mirror are reflected to the eye-glass; whereas in the latter the reader will see that he looks through the common eye-glass, which is in general more convenient.

The immensely powerful telescopes of Dr. Herschel are of a still different construction. This assiduous astronomer has made several specula, which are so perfect as to bear a magnifying power of more than

six thousand times in diameter on a distant object. The object is reflected by a mirror as in the Gregorian telescope, and the rays are intercepted by a lens at a proper distance, so that the observer has his back to the object, and looks through the lens at the mirror. The magnifying power will in this case be the same as in the Newtonian telescope; but there not being a second reflector, the brightness of the object viewed in the Herschelian is greater than that in the Newtonian or Gregorian telescope. In conclusion, sir Isaac Newton's excellent maxim must not be omitted: "The art," says he, "of constructing good microscopes and telescopes may be said to depend on the circumstance of making the last image as large and distinct and luminous as possible."

There are some instruments of rather an amusing than a useful description, the effects of which depend on a proper combination of plane or convex glasses. Our limits will not admit the notice of more than two of this kind, namely, the magic lanthorn, and the camera obscura. The former is a microscope upon the same principles as the solar microscope, and may be used with good effect for magnifying small transparent objects; but in general it is applied to the purpose of amusement, by casting the image of a small transparent painting on glass upon a white wall or screen, at a proper distance from the instrument.

Let a candle or lamp C (fig. 8) be placed in the inside of a box, so that the light may pass through the plano-convex lens NN, and strongly illuminate the object OB; which is a transparent painting on glass, inverted and moveable before NN, by means of a sliding piece in which the glass is set or fixed. This illumination is still more increased by the reflection of light from a concave mirror SS, placed at the other end of the box, which causes the light to fall upon the lens NN, as represented in the figure. Lastly, a lens LL, fixed in a sliding tube, is brought to the requisite distance from the object OB, and a large erect image IM is formed upon the opposite wall.

The camera obscura has the same relation to the telescope as the solar microscope has to the common double microscope, and is thus constructed:

Let CD (fig. 12) represent a darkened chamber perforated at L, where a convex lens is fixed, the curvature of which is such, that the focus of parallel rays falls upon the opposite wall. Then if AB is an object at such a distance that the rays which proceed from any given point of its surface to the lens L may be esteemed parallel, an inverted picture will be formed on the opposite wall; for the pencil which proceeds from A will converge to *a*, and the pencil which proceeds from B will converge to *b*, and the intermediate points of the object will be depicted between *a* and *b*.

For the use of painters these instruments are now constructed in a very convenient mode. The lens is made to slide in a small wooden box, so as to be easily adjusted to a proper focus; and the image falls upon a plane mirror, placed obliquely at the back part of the box, from which it is reflected on a piece of ground glass, or on a sheet of white paper extended over. The picture which is thus formed is very tender and beautiful. The moving objects give it animation; and the outline formed is so perfect that it may be easily traced, even by a person who is little skilled in drawing or perspective.

Of the doctrine of colours, or chromatics.—In some of the preceding sections we had occasion to use the word aberration, though we had not then an opportunity of explaining it; since in the optics of the mind, as well as in those of which we are treating, when too many images are presented at once, a certain degree of confusion must necessarily ensue. As there is no "royal road to science," so philosophy gradually developes her secrets, and the possession of one fact prepares the mind for another.

We have hitherto assumed as a principle, that a convex lens unites in one point, which we have called the focus, all the rays proceeding from any given point of an object. If this was exactly the case, the images, formed by these glasses would be perfectly distinct and unconfused. The principle, however, holds strictly true only with respect to those rays which pass nearly through the centre of the lens; for those which pass near the extremities or edges of the glass, meet in foci still more distant, and from this multiplication of images great indistinctness results.

To show the reason of this it is necessary to have recourse to a figure. Let PP then (Plate XCVIII. fig. 10.) be a convex lens; and E*e* an object, the point E of which corresponds with the axis of the lens, and sends forth the rays EM, EN, EA, EM, and EN, all of which reach the surface of the glass, but in different parts. Now it is manifest, upon the principles already explained, that the ray EA, which passes through the middle of the glass, suffers no refraction; the rays EM, EM, also, which pass through near to EA, will be converged to a focus at F, which we have been accustomed to consider as the focus of the lens. But the rays EN, EN, which are nearer to the edge of the glass, will be differently refracted; and will meet about G, nearer to the lens, where they will form another image G*g*. Hence it is evident that the first image F*f* is formed only by the union of those rays which pass very near the centre of the lens; but, in truth, as the rays of light proceeding from every point of an object are very numerous, there is a succession of images formed according to the parts of the lens where they penetrate, which necessarily produces great indistinctness and confusion; and this is what is meant by the word aberration.

This confusion or dispersion of the rays is increased in proportion as the arcs PAP, PBP, are larger segments of their respective circles: hence in very thick and convex lenses the aberration is such as to be intolerable. Even in the object-glasses of telescopes, though they are made thin, and are segments of large circles, and though from these reasons the dispersion of the rays may be insensible in itself, still the magnifying power multiplies it as often as the object itself. Hence the greater the magnifying power, the smaller should be the aperture of the object-glass: and when the dispersion of the rays is very great, the defect is in some degree remedied by covering the edge of the lens with an opaque ring; but in this case, while distinctness is restored, the brightness of the image is necessarily diminished. Opticians have therefore endeavoured to form such combinations of lenses, both concave and convex, varying in their respec-

tive foci, as must unite all the rays in a single point, and thus present a distinct image. Calculations have been formed for these combinations, but the hand of the artist has never been able to bring the speculations of theorists to entire perfection.

The plan most generally adopted by practical opticians is, to combine two shallow lenses together in such a manner that they act as a single lens. They use often plano-convex, for that figure admits of less aberration than any other; but shallow lenses of a double-convex kind will answer. In this combination the lenses are set near together, so that the second lens acts only in bringing the rays which pass through the first to a nearer focus. Thus in Plate XCVIII. fig. 9, AB and CD are two lenses of this description; and the focus of AB would be at F, but, by the second lens, the rays are made to converge at a nearer focus *f*: thus they act together as a single lens of double their magnifying power, with this advantage; that as the curvatures of both conjointly, are less than the curvature of a single lens of equal power, the aberration is greatly lessened.

The aberration which we have been describing results from the spherical form of the glasses; but there is another kind of aberration, which depends immediately upon the nature and properties of light itself. Each ray or beam of light, indeed, which gives us the sensation of white, is found to be compounded of seven other rays; and these component rays are each of them differently refrangible. Hence objects viewed through very convex glasses are often found to have their edges tinged with various colours. This effect was long felt, but it remained for Newton to explain the cause.

In the short history contained in the first part of this article, the discoveries on colours were briefly related; but it will perhaps be satisfactory to the reader to have the experiment described in the words of Newton himself, which will at the same time afford an example of the style and manner of this first of philosophers.

"In a very dark chamber, at a round hole F (Plate XCVIII. fig. 14), about one-third of an inch broad (says he), made in the shutter of a window, I placed a glass prism ABC, whereby the beam of the sun's light, SF, which came in at that hole, might be refracted upwards, toward the opposite wall of the chamber, and there form a coloured image of the sun, represented at PT. The axis is of the prism (that is, the line passing through the middle of the prism, from one end of it to the other end, parallel to the edge of the refracting angle) was in this and the following experiments perpendicular to the incident rays. About this axis I turned the prism slowly; and saw the refracted light on the wall, or coloured image of the sun, first to descend, and then to ascend. Between the descent and ascent, when the image seemed stationary, I stopped the prism, and fixed it in that posture.

"Then I let the refracted light fall perpendicularly upon a sheet of white paper, MN, placed at the opposite wall of the chamber; and observed the figure and dimensions of the solar image PT, formed on the paper by that light. This image was oblong, and not oval, but terminated by two rectilinear and parallel sides, and two semicircular ends. On its sides it was bounded pretty distinctly; but on its ends very confusedly and indistinctly, the light there decaying and vanishing by degrees. At the distance of $18\frac{1}{2}$ feet from the prism, the breadth of the image was about $2\frac{1}{8}$ inches, but its length was about $10\frac{1}{4}$ inches, and the length of its rectilinear sides about 8 inches; and ACB, the refracting angle of the prism, whereby so great a length was made, was 64°. With a less angle the length of the image was less, the breadth remaining the same. It is farther to be observed, that the rays went on in straight lines from the prism to the image; and therefore at their going out of the prism had all that inclination to one another from which the length of the image proceeded. This image PT was coloured, and the more eminent colours lay in this order from the bottom at T to the top at P; red. orange, yellow, green, blue, indigo, violet, together with all their intermediate degrees, in a continual succession, perpetually varying.

The philosopher continued his experiments, and by making the rays thus decompounded pass, as was formerly related, through a second prism, he found that they did not admit of farther decomposition; and that objects placed in the rays producing one colour always appeared to be of that colour. He then examined the ratio between the sines of incidence and refraction of these decompounded rays; and found that each of the seven primary colour-making rays, as they may be called, had certain limits within which they were confined. Thus, let the sine of incidence in glass be divided into fifty equal parts, the sine of refraction into air of the least and most refrangible rays will contain respectively 77 and 78 such parts. The sines of refraction of all the degrees of red will have the intermediate degrees of magnitude, from 77 to $77\frac{1}{8}$; orange from $77\frac{1}{8}$ to $77\frac{1}{5}$; yellow from $77\frac{1}{5}$ to $77\frac{1}{3}$; green from $77\frac{1}{3}$ to $77\frac{1}{2}$; blue from $77\frac{1}{2}$ to $77\frac{2}{3}$; indigo from $77\frac{2}{3}$ to $77\frac{7}{6}$; and violet from $77\frac{7}{9}$ to 78.

According to the properties of bodies in reflecting or absorbing these rays, the colours which we see in them are formed. If every ray falling upon an object was reflected to our eye it would appear white; if every ray was absorbed it would appear black; between these two appearances innumerable species of colours may be formed by reflection or transmission of the various combinations of the colour-making rays. If the rays also of light were not thus compounded, every object would appear of the same colour, and an irksome uniformity would prevail over the face of nature.

To leave, however, for the present, the further prosecution of this subject, and to return to that of the errors arising in optical glasses from the dispersion of the rays of light, it must be evident that, in proportion as any part of a glass bears a resemblance to the form of a prism, the component rays must be necessarily separated. The edges of every convex lens approach to this form; and it is on this account that the extremities of objects viewed through them are found to be tinged with coloured rays. In reality, as all the different colour-making rays are differently refrangible, in such a glass these different rays will have different foci, and will form their respective images at different distances from the glass. Thus imagine PP (Plate XCVIII. fig. 11) to be a double-convex lens, and OO an object situated at some distance from it. If the object OO was red, the rays proceeding from it would form a red image at R*r*; if it was violet, an image of that colour would be formed at V*v* nearer the

glass; and if the object was white, or any other combination of the colour-making rays, these rays would have their respective foci at different distances from the glass, and form a succession of images, in the order of the prismatic colours, between the space Rr and Vv.

This dispersion depends on the focal length of the glass, the space which the coloured images occupy being about the 28th part. Thus, if the glass is of 28 feet focus, the space between Rr and Vv will be about one foot, and so in proportion. Now when viewed through one eye-glass or more, this succession of images will seem to form but one image, but that very indistinct, and tinged with various colours; and as the red image Rr in the figure is largest, or seen under the greatest angle, the extreme parts of this confused image will be red, and a succession of the prismatic colours will be formed with this red fringe, as is frequently found in telescopes upon the old construction.

This defect in telescopes was long regarded as without a remedy; but who shall set bounds to the inventive powers of the human mind? It was in the different refractive powers of various media that a remedy was sought for this property in glasses, so adverse to the hopes and wishes of philosophers. Sir Isaac Newton had hinted the practicability of this plan; but he was too deeply engaged in the vast discoveries which the use of the reflector opened to his view, to pursue practically the idea. As water is known to have very different refractive powers from glass, the great Euler, proceeding upon the hint of Newton, projected an object-glass of two lenses, with water between them. The memoir of Euler excited powerfully the attention of Mr. Dollond, a practical optician in London; and after trying the refractive power of water combined with glass in the form of a prism, he conceived that the refractive powers of different glasses might serve to correct each other. He applied himself therefore to examine the qualities of every kind of glass he could procure, and found that the two which differed most essentially in their refractive powers were the common crown or window glass, and the white flint glass. He then formed two prisms, one of the white flint of an angle of about 25 degrees, and another of flint of 29. They refracted very nearly alike, but their power of making the colours diverge was very different. He next ground several others of crown glass, till he procured one which was equal as to the divergency of light with that of the flint glass. He placed them together, therefore, but in opposite directions, so as to counteract each other; and he found that the light which passed through them was perfectly white. This discovery, it was obvious, was immediately applicable to the object-glasses of telescopes. To make the glasses act as the two prisms, to refract the light in contrary directions, it was plain that the one must be concave and the other convex; and as the rays are to converge to a real focus, the excess of refraction must be in the canvex lens. As the convex lens is to refract most also, it appeared from his experiments that it must be of crown glass. He therefore employed two convex lenses of crown glass, with a concave lens of flint glass; and these are the telescopes most in use at present, and well known by the name of achromatic telescopes. Some opticians however, we believe, now construct them with two lenses, one convex and the other concave.

In fig. 18, *a* and *c* show the two convex lenses, and *bb* the concave one, of this telescope. They are all ground to spheres of different radii, according to the refractive powers of the different kinds of glass, and the intended focal distance of the object-glass of the telescope. According to Boscovich, the focal distance of the parallel rays for the concave lens is one-half, and for the convex glass one-third, of the combined focus. When put together they refract the rays in the following manner: Let *ab*, *ab* (fig. 18), be two red rays of the sun's light falling parallel on the first convex lens *c*. Supposing there was no other lens present but that one, they would then be converged into the lines *bc*, *be*, and at last meet in the focus *q*. Let the lines *gh*, *gh*, represent two violet rays falling on the surface of the lens. These are also refracted, and will meet in a focus; but as they have a greater degree of refrangibility than the red rays, they must of consequence converge more by the same power of refraction in the glass, and meet sooner in a focus, suppose at *r*. Let now the concave lens of flint glass *dd* be placed in such a manner as to intercept all the rays before they come to their focus. If this lens was made of the same materials, and ground to the same radius with the convex one, it would have the same power to cause the rays to diverge that the former had to make them converge. In this case, the red rays would become parallel, and move on in the line *oo*, *oo*: but the concave lens, being made of flint glass, and upon a shorter radius, has a greater refractive power, and therefore they diverge a little after they come out of it; and if no third lens was interposed, they would proceed diverging in the lines *opt*, *opt*; but, by the interposition of the third lens *ovo*, they are again made to converge, and meet in a focus somewhat more distant than the former, as at *x*. By the concave lens the violet rays are also refracted, and made to diverge: but, having a greater degree of refrangibility, the same power of refraction makes them diverge somewhat more than the red ones; and thus, if no third lens was interposed, they would proceed in such lines as *lmn*, *lmn*. As the differently-coloured rays then fall upon the third lens with different degrees of divergence, it is plain that the same power of refraction in that lens will operate upon them in such a manner as to bring them all together to a focus very nearly at the same point. The red rays, it is true, require the greatest power of refraction to bring them to a focus; but they fall upon the lens with the least degree of divergence. The violet rays, though they require the least power of refraction, yet have the greatest degree of divergence; and thus all meet together at the point *x*, or very nearly so. It was afterwards demonstrated by M. Zeiker of Petersburgh, that it is the lead used in the composition of the crown glass, which gives it this remarkable property of dispersing the extreme rays; and he found that this property was increased in proportion to the quantity of minium, or red lead, which was employed in the manufacture of the glass.

The more we investigate the works of nature, the greater reason have we to admire the wisdom of its author, and that wonderful adaptation of our organs, in the minuter particulars, to the general laws which pervade the universe. The subject before us affords a striking in-

stance to corroborate this remark. We have hitherto supposed the eye to be a lens capable only of enlarging and contracting, and consequently, from the description now given of the rays of light, it must be incapable of obviating the confusion which must arise from their different degrees of refrangibility. But here the use of that wonderful structure of parts, and the different fluids in the eye, is clearly seen. The eye is, in fact, a compound lens. Each fluid has its proper degree of refrangible power. The shape of the lenses is altered at will, according to the distance of the object; and the three substances having the proper powers of refrangibility, the effects of an achromatic glass are without difficulty produced by the eye, whose mechanical structure and exact arrangement of substances it is in vain for the art of man to imitate.

From what has been stated, the principal phenomena of colours may, without much difficulty, be explained.

If all the different-coloured rays which the prism affords are reunited in the focus of a convex lens, the product will be white; yet these same rays, which, taken together, form white, give, after the point of their reunion, that is, beyond the point where they cross each other, the same colours as those which departed from the prism, put in a reversed order, by the crossing of the rays: the reason of which is clear; for the ray being white before it was divided by the prism, must necessarily become so by the reunion of its parts, which the difference of refrangibility had separated, and this reunion cannot in any manner tend to alter or destroy the nature of the colours; it follows then that they must appear again beyond the point of crossing. A similar effect will be produced, if the dispersed rays are received from the prism upon a concave reflector. In the focus of the reflector they will unite and form a white or colourless image of the sun. But it is curious to remark, that if any one of thé colours is stopped in its progress to the reflector by the interposition of a wire, or any other slender opaque body, then the image in the focus will be an imperfect white, or a mixed colour. Beyond the focus the rays separate again, as in the case of their passing through a convex lens, and form the coloured spectrum, only the order of the colours from the crossing of the rays is inverted.

In the same manner, if we mix a certain proportion of red colour with orange, yellow, green, blue, indigo, and violet, a colour will be produced which resembles that which is made by mixing a little black with white, and which would be entirely white if some of the rays were not lost or absorbed by the grossness of the colouring matter.

A colour nearly approaching to white, is also formed by colouring a piece of round pasteboard with the different prismatic colours, and causing it to be turned round so rapidly, that no particular colour can be perceived.

If to a single ray of the sun, divided by the prism, which will then form an oblong coloured spectrum, a thick glass deeply coloured with one of the primitive colours is applied, for example red, the light which passes through will appear red only, and will form a round image.

The component rays of light may be separated by other means than by the prism. It is a common amusement of children to blow round bubbles of soap, dissolved in water, from the bowl of a tobacco-pipe; and these bubbles will, in the sunshine, commonly exhibit most of the prismatic colours. Indeed the same thing may be at any time observed in the bubbles made by agitating soap and water. As these bubbles are thin vesicles of the matter dissolved in the fluid, they are commonly supposed to vary in their thickness, and to act in this way in separating the rays. If two pieces of glass, also of an unequal surface, are gently pressed together, round the point of contact circles of different colours will be formed. Sir Isaac Newton employed for this experiment the object-glasses of two telescopes of a long focus, which it is well known are much less convex than the common spectacle-glasses. One was a plano-convex for a telescope of 14 feet, and the other a double-convex for one of 50 feet. Upon pressing the glasses close together, at the point of contact circles of coloured light appeared, and they increased in number and size as the pressure was increased. The order of the colours next to the point in contact, which was black, was blue, yellow, white, yellow, and red. Without this circle another appeared, consisting of violet, blue, green, yellow, and red. A third succeeded of purple, blue, green, yellow, and red; and a fourth of green and red. The outer circles were paler, and more obscure, than those within.

The appearance of these circles is delineated in fig. 15, where *a, b, c, d, e; f, g, h, i, k; l, m, n, o, p; q, r; s, t; u, x; y, z;* denote the colours in order from the centre, namely, black, blue, green, yellow, red; purple, blue, green, yellow, red; green, red; greenish blue, red; greenish blue; redish white.

Various theories have been offered to account for this seperation of the rays, but none of them are quite satisfactory. Perhaps if Mr. Deleval's experiments on transmitted and reflected light were carefully pursued, they might afford some illustration of the phenomenon.

If two thick glasses, the one red and the other green, are placed one upon another, they will produce a perfect opacity, though each of them, taken separately, is transparent; because the one permits the red rays only to pass through it, and the other only green ones; therefore when these two glasses are united, neither of those kind of rays can reach the eye; because the first permits only red rays to pass, and green ones are the only rays which the second can transmit.

If the rays of the sun are made to fall very obliquely upon the interior surface of a prism, the violet-coloured rays will be reflected, and the red, &c. will be transmitted; if the obliquity of incidence is augmented the blue will be also reflected, and the other transmitted; the reason of which is, that the rays which have the most refrangibility are also those which are the easiest reflected.

In whatever manner we examine the colour of a single prismatic ray, we shall always find, that neither refraction, reflection, nor any other means, can make it forego its natural hue; but if we examine the artificial colouring of bodies by a microscope, it will appear a rude heap of colours, unequally mixed. If we mix a blue and yellow to make a common green, it will appear moderately beautiful to the naked eye; but when we regard it with microscopic attention, it seems a confused mass of yellow and blue parts, each particle reflecting but one separate colour,

Of the rainbow, and other remarkable phenomena of light.—Since the rays of light are found to be decompounded by refracting surfaces, we can no longer be surprised at the changes produced in any object by the intervention of another. The vivid colours which gild the rising or the setting sun, must necessarily differ from those which adorn its noon-day splendour. There must be the greatest variety which the liveliest fancy can imagine. The clouds will assume the most fantastic forms, or will lour with the darkest hues, according to the different rays which are reflected to our eyes, or the quantity absorbed by the vapours in the air. The ignorant multitude will necessarily be alarmed by the sights in the heavens; by the appearance at one time of three, at another of five, suns; of circles of various magnitudes round the sun or moon; and thence conceive that some fatal changes must take place in the physical or the moral world, some fall of empires or tremendous earthquake: while the optician contemplates them merely as the natural and beautiful effects produced by clouds or vapour in various masses upon the rays of light.

One of the most beautiful and common of these appearances deserves particular investigation, as, when this subject is well understood, there will be little difficulty in accounting for others of a similar nature, dependant on the different refrangibility of the rays of light. Frequently, when our backs are turned to the sun, and there is a shower either around us, or at some distance before us, a bow is seen in the air, adorned with all or some of the seven primary colours. The appearance of this bow, in poetical language called the iris, and in common language the rainbow, was an inexplicable mystery to the ancients; and, though now well understood, continues to be the subject of admiration to the peasant and the philosopher.

We are indebted to sir Isaac Newton for the explanation of this appearance; and by various easy experiments we may convince any man that his theory is founded on truth. If a glass globe is suspended in the strong light of the sun, it will be found to reflect the different prismatic colours exactly in proportion to the position in which it is placed: in other words, agreable to the angle which it forms with the spectator's eye and the incidence of the rays of light. The fact is, that innumerable pencils of light fall upon the surface of the globe, and each of these is separated as by a prism. To make this matter still clearer, let us suppose the circle BAW (Plate XCVIII. fig. 16) to represent the globe, or a drop of rain, for each drop may be considered as a small globe of water. The red rays, it is well known, are least refrangible, they will therefore be refracted, agreable to their angle of incidence, to a certain point A in the most distant part of the globe; the yellow, the green, the blue, and the purple rays, will each be refracted to another point. A part of the light, as refracted, will be transmitted, but a part will also be reflected; the red rays at the point A, and the others at certain other points, agreeably to their angle of refraction.

It is very evident that if the spectator's eye is placed in the direction of MW, or the course of the red-making rays, he will only distinguish the red colour; if in another situation, he will see only by the yellow rays; in another by the blue, &c.: but as in a shower of rain there are drops at all heights and all distances, all those that are in a certain position with respect to the spectator will reflect the red rays, all those in the next station the orange, those in the next the green, &c.

To avoid confusion let us, for the present, imagine only three drops of rain, and three degrees of colours in the section of a bow (Plate XCVIII, fig. 20). It is evident that the angle CEP is less than the angle BEP, and that the angle AEP is the greatest of the three. This largest angle then is formed by the red rays, the middle one consists of the green, and the smallest is the purple. All the drops of rain, therefore, that happen to be in a certain position to the eye of the spectator, will reflect the red rays, and form a band or semicircle of red; those again in a certain position will present a band of green, &c. If he alters his station, the spectator will still see a bow, though not the same bow as before: and if there are many spectators they will each see a different bow, though it appears to be the same.

There are sometimes seen two bows, one formed as has been described, the other appearing externally to embrace the primary bow, and which is sometimes called a secondary or false bow, because it is fainter than the other; and what is most remarkable is, that in the false bow the order of the colours appears always reversed.

In the true primary bow we have seen that the rays of light arrive at the spectator's eye after two refractions and one reflection; in the secondary bow the rays are sent to our eyes after two refractions and two reflections, and the order of the colours is reversed, because in this latter case the light enters at the inferior part of the drop, and is transmitted through the superior. Thus (fig. 19) the ray of light which enters at B is refracted to A, whence it is reflected to P, and again reflected to W, where, suffering another refraction, it is sent to the eye of the spectator. The colours of this outer bow are fainter than those of the other, because, the drop being transparent, a part of the light is transmitted, and consequently lost, at each reflection.

The phenomenon assumes a semicircular appearance, because it is only at certain angles that the refracted rays are visible to our eyes. The least refrangible, or red rays, make an angle of 42 degrees two minutes, and the most refrangible or violet rays an angle of 40 degrees 17 minutes. Now if a line is drawn horizontally from the spectator's eye, it is evident that angles formed with this line, of a certain dimension in every direction, will produce a circle; as will be evident by only attaching a cord of a given length to a certain point, round which it may turn as round its axis, and in every point will describe an angle with the horizontal line of a certain and determinate extent.

Let HO, for instance (Plate XCVIII. fig. 19), represent the horizon, BW a drop of rain at any altitude, SB a line drawn from the sun to the drop, which will be parallel to a line SM drawn from the eye of the spectator to the sun. The course of part of the decompounded ray SB may be first by refraction from B to A, then by reflection from A to W, lastly by refraction from W to M. Now all drops, which are in such a situation that the incident and emergent rays SB, MW, produced through them make the same angle SNM, will be the means of exciting in the spectators the same idea of colour. Let the MW turn upon HO as an axis, till W meets the horizon

on both sides, and the point W will describe the arc of a circle: and all the drops placed in its circumference will have the property we have mentioned, of transmitting to the eye a particular colour. When the plane HMWA is perpendicular to the horizon, the line MW is directed to the vertex of the bow, and WK is its alitude.

This altitude depends on two things, the angle between the incident and emergent rays, and the hight of the sun above the horizon; for since SM is parallel to SN, the angle SNM is equal to NMI: but SMH, the altitude of the sun, is equal to KMI; therefore the altitude of the bow WMK, which is equal to the difference between WMI and KMI, is equal to the difference between the angles made by the incident and emergent rays and the altitude of the sun.

The angle between the incident and emergent rays is different for the different colours, as was already intimated; for the red, or least refrangible, rays, it is equal to 42° 2′; for the violet, or most refrangible, it is equal to 40° 17′; consequently when the sun is more than 42° 2′ above the horizon, the red colour cannot be seen; when it is above 40° 17′ the violet colour cannot be seen.

The secondary bow is made in a similar manner; but the sun's rays suffer, in this case, two reflections within the drop. The ray SB (Plate XCVIII fig. 19) is decompounded at B; and one part is refracted to A, thence reflected to P, and from P reflected to W, where it is refracted to M. The angle between the incident and emergent rays SNM is equal as before to NMI; and NMK, the height of the bow, is equal to the difference between the angle made by the incident and emergent rays and the height of the sun. In this case the angle SNM, for the red rays, is equal to 50° 7′, and for the violet rays it is equal to 54° 7′; consequently the upper part of the secondary bow will not be seen when the sun is above 54° 7′ above the horizon, and the lower part of the bow will not be seen when the sun is 50° 7′ above the horizon.

In the same manner the innumerable bows might be formed by a greater number of reflections within the drops; but as the secondary is so much fainter than the primary, that all the colours in it are seldom seen, for the same reason a bow made with three reflections would be fainter still, and in general altogether imperceptible. Since the rays of light, by various reflections and refractions, are thus capable of forming, by means of drops of rain, the bows which we so frequently see in the heavens, it is evident that there will be not only solar and lunar bows, but that many striking appearances will be produced by drops upon the ground, or air on the agitated surface of the water. Thus a lunar bow will be formed by rays from the moon affected by drops of rain; but as its light is very faint in comparision with that of the sun, such a bow will very seldom be seen, and the colours of it, when seen, will be faint and dim.

The marine or sea bow is a phenomenon sometimes observed in a much agitated sea; when the wind, sweeping part of the tops of the waves, carries them aloft, so that the sun's rays, falling upon them, are refracted, &c. as in a common shower, and paint the colours of the bow.

Rohault mentions coloured bows on the grass, formed by the refraction of the sun's rays in the morning dew.

Dr. Langwith, indeed, once saw a bow lying on the ground, the colours of which were almost as lively as those of the common rainbow. It was extended several hundred yards. It was not round, but oblong, being, as he conceived, the portion of an hyperbola. The colours took up less space, and were much more lively, in those parts of the bow which were near him than in those which were at a distance.

The drops of rain descend in a globular form, and thence we can easily account for the effects produced by them on the rays of light; but in different states of the air, instead of drops of rain, vapour falls to the earth in different forms of sleet, snow, and hail. In the two latter states there cannot be a refraction of the rays of light; but in the former state, when a drop is partly in a congealed and partly in a fluid form, the rays of light will be differently affected, both from the form of the drop and its various refracting powers. Hence we may expect a variety of curious appearances in the heavens; and to these drops, in different states, we may attribute the formation of halos, parhelia, and many other phenomena, detailed in the Philosophical Transactions, or in the histories of every country.

The halo, or corona, is a luminous circle surrounding the sun, the moon, a planet, or a fixed star. It is sometimes quite white, and sometimes coloured like the rainbow. Those which have been observed round the moon or stars are but of a very small diameter; those round the sun are of different magnitudes, and sometimes immensely great. When coloured, the colours are fainter than those of the rainbow, and appear in a different order, according to their size. In those which sir Isaac Newton observed in 1692, the order of the colours, from the inside next the sun, was in the innermost blue, white, red; in the middle purple, blue, green, yellow, pale red; in the outermost pale blue, and pale red. Huygens observed one red next the sun, and pale blue at the extremity. Mr. Weidler has given an account of one yellow on the inside, and white on the outside. In France one was observed, in which the order of the colours was white, red, blue, green, and a bright red on the outside.

Artificial coronas may be made in cold weather, by placing a lighted candle in the midst of a cloud of steam; or if a glass window is breathed upon, and the flame of a candle placed at some distance from the window, while the operator is also at the distance of some feet from another part of the window, the flame will be surrounded with a coloured halo.

When M. Bouguer was at the top of mount Pichinca, in the Cordilleras, he and some gentlemen who accompanied him, observed a most remarkable phenomenon. When the sun was just rising behind them, and a white cloud was about thirty paces from them, each of them observed his own shadow (and no other) projected upon it. All the parts of the shadow were distinct; and the head was adorned with a kind of glory, consisting of three or four concentric crowns, of a very lively colour, each exhibiting all the varieties of the primary rainbow, and having the circle red on the outside.

Similar to this appearance was one which occurred to Dr. M'Fait, in Scotland. This gentleman observed a rainbow round his shadow in a mist, when he was situated on an eminence above it. In this situation the whole country appeared to be immersed in a vast deluge,

and nothing but the tops of hills appeared here and there above the flood; at another time he observed a double range of colours round his shadow.

The parhelia, or mock suns are the most splendid appearances of this kind. We find these appearances frequently adverted to by the ancients, who generally considered them as formidable omens. Four mock suns were seen at once by Scheiner at Rome, and by Muschenbroek at Utrecht; and seven were observed by Hevelius at Sedan, in 1661.

The parhelia generally appear about the size of the true sun, not quite so bright, though they are said sometimes to rival their parent luminary in splendour. When there are a number of them they are not equal to each other in brightness. Externally they are tinged with colours like the rainbow. They are not always round, and have sometimes a long fiery tail opposite the sun, but paler towards the extremity. Dr. Haller observed one with tails extending both ways. Mr. Weidler saw a parhelion with one tail pointing up and another downward, a little crooked; the limb which was farthest from the sun being of a purple colour, the other tinged with the colours of the rainbow.

Coronas generally accompany parhelia: some coloured, and others white. There is also, in general, a very large white circle, parallel to the horizon, which passes through all the parhelia; and, if it was entire, would go through the centre of the sun: sometimes there are arches of smaller circles concentric to this, and touching the coloured circles which surround the sun; they are also tinged with colours, and contain other parhelia.

One of the most remarkable appearances of this kind was that which was observed at Rome by Scheiner, as intimated above; and this may serve as a sufficient instance of the parhelion.

This celebrated phenomenon is represented in Plate XCVIII. fig. 17, in which A is the place of the observer, B his zenith, C the true sun, and AB a plane passing through the observer's eye, the true sun, and the zenith. About the sun C there appeared two concentric rings, not complete, but diversified with colours. The lesser of them, DEF, was fuller, and more perfect; and though it was open from D to F, yet those ends were perpetually endeavouring to unite, and sometimes they did so. The outer of these rings was much fainter, so as scarcely to be discernible. It had, however, a variety of colours, but was very inconstant. The third circle, KLMN, was very large, and entirely white, passing through the middle of the sun, and every where parallel to the horizon. At first this circle was entire; but towards the end of the phenomenon it was weak and ragged, so as hardly to be perceived from M towards N.

In the intersection of this circle and the outward iris GKI, there broke out two parhelia, or mock suns, N and K, not quite perfect, K being rather weak, but N shone brighter and stronger. The brightness of the middle of them was something like that of the sun; but towards the edges they were tinged with colours like those of the rainbow, and they were uneven and ragged. The parhelion N was a little wavering; and sent out a spiked tail NP, of a colour somewhat fiery, the length of which was continually changing.

The parhelia at L and M, in the horizontal ring, were not so bright as the former, but were rounder, and white, like the circle in which they were placed. The parhelion N disappeared before K; and while M grew fainter, K grew brighter, and vanished the last of all.

It is to be observed farther, that the order of the colours in the circles DEF, GKN, was the same as in the common halos, namely, red next the sun; and the diameter of the inner circle was also about 45°, which is the usual size of a halo.

Parhelia have been seen for one, two, three, and four hours together; and in North America they are said to continue some days, and to be visible from sun-rise to sun-set. When they disappear it sometimes rains, or snow falls in the form of oblong spiculæ.

Mr. Wales, says that at Churchill, in Hudson's-bay, the rising of the sun is always preceded by two long streams of red light. These rise as the sun rises; and, as they grow longer, begin to bend towards each other, till they meet directly over the sun, forming there a kind of parhelion, or mock sun.

These two streams of light, he says, seem to have their source in two other parhelia, which rise with the true sun; and in the winter season, when the sun never rises above the haze or fog which he says is constantly found near the horizon, all these accompany him the whole day, and set with him in the same manner as they rise. Once or twice he saw a fourth parhelion under the true sun; but this, he adds, is not common.

The cause of these is apparently the reflection of the sun's light and image from the thick and frozen clouds in the northern atmosphere, accompanied also with some degree of refraction. To enter upon a mathematical analysis of these phenomena would be only tedious, and very foreign to our purpose. From what has been said upon this subject it is evident, that all the phenomena of colours depend upon two properties of light, the refrangibility and reflexibility of its rays.

Of the inflection of light.—The direction of the rays of light is changed, as we have seen, in their approach to certain bodies, by reflection and refraction; and consequently we must admit that there is some power in these bodies by which such effects are universally produced. If reflection was produced simply by the impinging of particles of light on hard or elastic bodies, or if they were in themselves elastic, the same effects would follow as in the impulse of other elastic bodies; but the angle of incidence could not be equal to the angle of reflection, unless the particles of light were perfectly elastic, or the bodies on which they impinged were perfectly elastic. Now we know that the bodies on which these particles impinge are not perfectly elastic; and also that if the particles of light were perfectly elastic, the diffusion of light from the reflecting bodies would be very different from its present appearance: for as no body can be perfectly polished, the particles of light, which are so inconceivably small, would be reflected back by the inequalities on the surface in every direction; consequently we are led to this conclusion, that the reflecting bodies have

a power which acts at some little distance from their surfaces.

If this reasoning is allowed to be just, it necessarily follows, that if a ray of light, instead of impinging on a body, should pass so near to it as to be within the sphere of that power which the body possesses, it must necessarily suffer a change in its direction. Actual experiments confirm the truth of this position; and to the change in the direction of a particle of light, owing to its nearness to a body, we give the name of inflection.

From one of these experiments, made by sir Isaac Newton, the whole of this subject will be easily understood. At the distance of two or three feet from the window of a darkened room, in which was a hole three-fourths of an inch broad, to admit the light, he placed a black sheet of pasteboard, having in the middle a hole about a quarter of an inch square, and behind the hole the blade of a sharp knife, to intercept a small part of the light which would otherwise have passed through the hole. The planes of the pasteboard and blade were parallel to each other; and when the pasteboard was removed at such a distance from the window, as that all the light coming into the room must pass through the hole in the pasteboard, he received what came through this hole on a piece of paper two or three feet beyond the knife, and perceived two streams of faint light shooting out both ways from the beam of light into the shadow. As the brightness of the direct rays obscured the fainter light, by making a hole in his paper he let them pass through, and had thus an opportunity of attending closely to the two streams, which were nearly equal in length, breadth, and quantity of light. That part which was nearest to the sun's direct light was pretty strong for the space of about a quarter of an inch, decreasing gradually till it became imperceptible; and at the edge of the knife it subtended an angle of about twelve, or at most, fourteen degrees.

Another knife was then placed opposite to the former, and he observed, that when the distance of their edges was about the four-hundredth part of an inch, the stream divided in the middle, and left a shadow between the two parts, which was so dark, that all light passing between the knives seemed to be bent aside to one knife or the other; as the knives were brought nearer to each other, this shadow grew broader, till upon the contact of the knives the whole light disappeared.

Pursuing his observations upon this appearance, he perceived fringes, as they may be termed, of different-coloured light, three made on one side by the edge of one knife, and three on the other side by the edge of the other; and thence concluded, that as in refraction the rays of light are differently acted upon, so are they at a distance from bodies by inflection; and by many other experiments of the same kind he supported his position, which is confirmed by all subsequent experiments.

We may naturally conclude, that from this property of inflection some curious changes will be produced in the appearances of external objects. If we take a piece of wire of a less diameter than the pupil of the eye, and place it between the eye and a distant object, the latter will appear magnified (Plate XCVIII. fig. 21). Let A be a church-steeple, B the eye, C the wire. The rays by which the steeple would have been otherwise seen are intercepted by the wire; and it is now seen by inflected rays, which make a greater angle than the direct rays, and consequently the steeple will be magnified.

In nearly shutting the eyes, and looking at a candle, there appear rays of light extending from it in various directions, like comets' tails; for the light, in passing through the eye-lashes, is inflected; and consequently many separate beams will be formed, diverging from the luminous object. The power of bodies to inflect the rays of light passing near to them will produce different effects, according to the nature of the rays acted upon; consequently a separation will take place in the differently refrangible rays, and those fringes which were taken notice of by Sir Isaac Newton will appear in other objects which are seen by the means of inflected rays. From considering thus the action of bodies upon light, we come to this general conclusion, for which we are indebted to our great philosopher: that light, as well as all other matter, is acted upon at a distance; and that reflection, refraction, and inflection, are owing to certain general laws in the particles of matter, which are equally necessary for the preservation of the beautiful harmony in the object nearest to us, and to produce by their joint action that great law by which the greater bodies in their system are retained in their respective orbits.

OPTION. Every bishop, whether created or translated, is bound immediately after confirmation, to make a legal conveyance to the archbishop of the next avoidance of such dignity or benefice belonging to the see, as the said archbishop shall choose, which is therefore called an option.

OR, in heraldry, denotes yellow, or gold-colour. See Heraldry.

ORANGE. See Citrus.

ORBICULARIS. See Anatomy.

ORBIT. See Astronomy.

ORCHARD, a plantation of fruit-trees. In planting an orchard great care should be taken that the soil is suitable to the trees planted in it; and that they are procured from a soil nearly of the same kind, or rather poorer than that laid out for an orchard. As to the situation, an easy rising ground, open to the south-east, is to be preferred. Mr. Miller recommends planting the trees four-score feet asunder, but not in regular rows; and would have the ground between the trees plowed, and sown with wheat and other crops, in the same manner as if it was clear from trees; by which means the trees will be more vigorous and healthy, will abide much longer, and produce better fruit. If the ground has been pasture, the green sward should be plowed in the spring before the trees are planted; and if it is suffered to lie a summer fallow, it will greatly mend it, provided it is stirred two or three times to rot the grass, and prevent the growing of weeds. At Michaelmas it should be plowed pretty deep, in order to make it loose for the roots of the trees, which if the soil is dry, should be planted in October; but if it is moist, the beginning of March will be a better season. If several sorts of fruit-trees are to be planted on the same spot, you should observe to plant the largest-growing trees backwards, and so proceed to those of less growth, continuing the same

method quite through the whole plantation; by which means the sun and air will more easily pass through the whole orchard. When you have planted the trees, you should support them with stakes, to prevent their being blown out of the ground by the wind; and the following spring, if the season should prove dry, cut a quantity of green turf, and lay it about the roots, with the grass downwards; by which means a great expense of watering will be saved, and after the first year they will be out of danger. Whenever you plow the ground betwixt these trees, you must be careful not to go too deep amongst their roots, which would greatly damage the trees; but if you do it cautiously, your stirring the face of the ground will be of great service to them: though you should observe, never to sow too near the tree, nor to suffer any great rooting weeds to grow about them; because this would starve them, by exhausting the goodness of the soil, which every two or three years should be mended with dung or other manure. These trees, after they are planted out, will require no other pruning besides cutting off their bad branches, or such as cross each other.

ORCHIS, *fool-stones*, a genus of the gynandria diandria class of plants, the corolla of which is of a corniculated form; and its fruit is an oblong unilocular capsule, containing numerous scobiform seeds.

The essential character is, nect. a horn or spur behind the flower. There are 50 species of this genus, which exceedingly resembles the ophrys. The most remarkable species are the following:

1. The mascula, or male fool-stones, has a root composed of two bulbs, crowned with oblong, broad, spotted leaves; upright stalks, a foot high, with one or two narrow amplexicaule leaves, and terminated by a long spike of reddish-purple flowers having the petals reflexed backward; a quadrilobed crenated lip to the nectarium, and an obtuse horn. The flower of this species possesses a very agreeable odour.

2. The morio, or female orchis, has a few amplexicaule leaves; and terminated by a short loose spike of flowers, having convenient petals, a quadrifid crenated lip to the nectarium, and an obtuse horn.

3. The militaris, or man-orchis, has erect flower-stalks, eight or ten inches high, terminated by a loose spike of ash-coloured and reddish flowers, having confluent petals; a quinquefid, rough, spotted lip to the nectarium, and an obtuse horn. The structure of the flowers exhibits the figure of a naked man; and is often of different colours in the same flower, as ash-colour, red, brown, and dark-striped.

All the orchises are very hardy perennials, with bulbous fleshy roots. The flowers appear in May, June, and July, but principally in June: their mode of flowering is universally in spikes, many flowers in each spike; and each flower is composed of five petals in two series, and a nectarium. The season for removing them is in summer, after they have done flowering, when their leaves and stalks decay: plant them three inches deep, and let them remain undisturbed several years; for the less they are removed the stronger they will grow.

This plant flourishes in various parts of Europe and Asia, and grows in our country spontaneously, and in great abundance. It is assiduously cultivated in the East; and the root of it forms a considerable part of the diet of the inhabitants of Turkey, Persia, and Syria. From it is made the alimentary powder called salep; which, prepared from foreign roots, is sold at five or six shillings per pound, though it might be furnished by ourselves at a sixth part of that price, if we chose to pay any attention to the culture of this plant. The orchis mascula is the most valued for this purpose. A dry, and not very fertile soil, is best adapted to its growth.

The properest time for gathering the roots is when the seed is formed, and the stalk is ready to fall; because the new bulb, of which the salep is made, is then arrived to its full maturity, and may be distinguished from the old one, by a white bud rising from the top of it, which is the germ of the orchis of the succeeding year.

ORDEAL, a form of trial, or of discovering innocence or guilt, formerly practised over almost all Europe, and which prevailed in England from the time of Edward the Confessor, till it was abolished by a declaration of Henry III. It was called purgatio vulgaris, or judicium, in opposition to bellum, or combat, the other form of purgation.

In England an offender, on being arraigned, and pleading Not guilty, had it in his choice to put himself upon God and his country; that is, upon the verdict of a jury; or upon God alone, on which account it was called the judgment of God, it being presumed that God would deliver the innocent. The more popular kinds of ordeal were those of red-hot iron and water: the first for freemen and people of fashion, and the last for peasants. Fire ordeal was performed either by taking up in the hand a piece of red-hot iron, of one, two, or three pounds weight; or else by walking barefoot and blindfold over nine red-hot ploughshares, laid at unequal distances; and if the party escaped unhurt, he was adjudged innocent, if not he was condemned as guilty. Water ordeal was performed either by plunging the bare arm up to the elbow in boiling water, and escaping unhurt thereby: or by casting the person suspected into a river or pond of water; and if he floated therein, without any action of swimming, it was deemed an evidence of guilt; but if he sunk he was acquitted. 4 Black. 340.

ORDER. See Architecture.

ORDERS, or Ordination. No person shall be admitted to the holy order of deacon under 23 years of age; nor to the order of priest unless he is 24 complete; and none shall be ordained without a title, that is, a nomination to some cure or benefice, and he shall have a testimonial of his good behaviour, for three years past, from three clergymen; and the bishop shall examine him, and if he sees cause may refuse him. And before he is ordained he shall take the oath of allegiance and supremacy before the ordinary, and subscribe the thirty-nine articles.

ORDINARY, in common and canon law, is one who has ordinary or immediate jurisdiction in ecclesiastical causes in such a place. In which sense archdeacons are ordinaries, though the appellation is more frequently given to the bishop of the diocese, who has the ordinary ecclesiastical jurisdiction. The arch bishop is the ordinary of the whole province, to visit and receive appeals from inferior judicatures.

ORDINATES, or Ordinate applicates, in geo-

metry, are parallel lines, MM, *mm* (Pl. CXII. Miscel. fig. 178), terminating in a curve, and bisected by a diameter, as AD. The half of these, as MP, *mp*, is properly the semiordinate, though commonly called ordinate.

ORDNANCE, a general name for all sorts of great guns used in war. See Gunnery.

Ordnance, *boring of*. Guns are thus boared: the piece A (Plate XCV. Observatory, fig. 7.) is placed upon two standards BB, by means of two journeys, turned round by a water-wheel; the breech D being introduced into the central line of the wheel, with the muzzle towards the sliding carriage E, which is pressed forwards by a ratch F and weights. Upon this sliding carriage is fixed truly horizontal and central to the gun, the drill-bar G, to the end of which is fixed a carp's tongue drill or cutter H; which, being pressed forward upon the piece whilst it is turning round, perforates the bore, which is afterwards finished with bars and cutters.

The machinery for boring of ordnance is sometimes put in motion by a steam-engine: and in this way, from 18 to 24 great guns have been boring at the same time; the borer in each piece being brought up to its proper place in the gun, by a lever and weights. In this method of bringing up the borer the pressure may always be made equable, and the motion of the borer regular; but the disadvantage is, that without due attention the borer may work up too far towards the breech, and the piece be spoiled. In the royal arsenal at Woolwich, only one piece is bored at a time in the same mill: the gun to be bored lies with its axis parallel to the horizon, and in that position is turned round its axis by means of wheel-work, moved by one or more horses. The borer is laid, as above described, in the direction of the axis of the gun, and is incapable of motion in any direction except that of its length; and in this direction it is constantly moved by means of a small rack-wheel, kept in proper motion by two men, who thus make the point of the borer so to bear against the part of the gun that is boring, as to pierce and cut it. The outside of the gun is smoothed at the same time by men with instruments fit for the purpose, whilst it turns round, so that the bore may be exactly in the centre of the metal. See Gregory's Mechanics.

Ordnance, *office of*, an office kept within the Tower of London, which superintends and disposes of all the arms, instruments, and utensils of war, both by sea and land, in all the magazines, garrisons, and forts, in Great Britain.

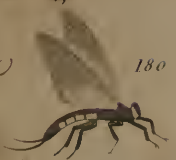
END OF VOL. II.


Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Fig. 5.
Fig. 6.
Fig 7
Fig. 8
Fig. 9.
Fig 10.
HUNNINGUEN
RHINE


195
Falco sacer
Sacre
196
Falco magnirostris
Great-billed Falcon
197
Falco milvus
Kite
199
Felis Lynx
200
Felis Leo
Lion
201
Felis Leo
Lioness
203
198
202
Felis catus
Domestic cat
Felis pardalis
Mexican cat
Ocelot

Fig 111.

180



Ephemera vulgata

181

Equus Caballus
Wild Horse

188

Erinaceus ecaudata
Madagascar hedgehog

189

Euphorbia officinalis

190

Exocoetus volitans
Flying fish

191

Falco chrysaetos
Golden Eagle

193

Falco Gallicus
French Eagle

192

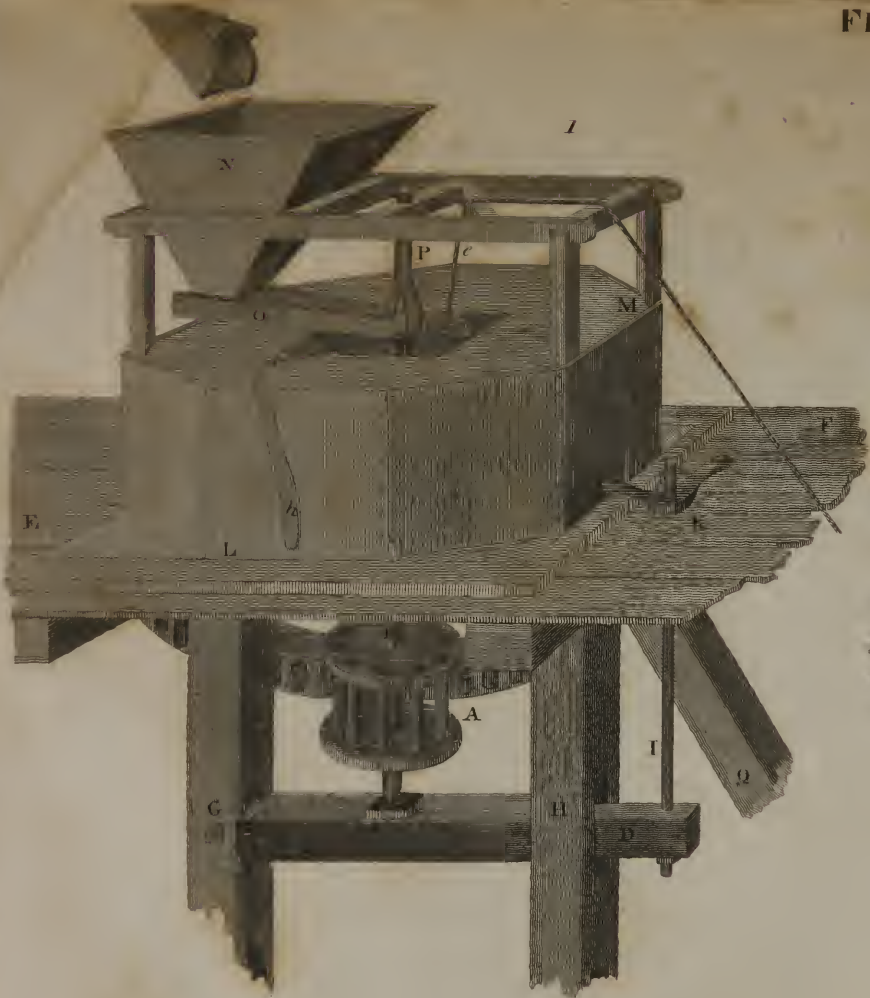
Falco litho falco
Stone Falcon

194

Falco haliaetus
Bald Buzzard.

FLOUR MILLS

1



2

3

4

5

Engraved by H. Anderson

204

Felis tigris
Tiger

205

Felis tigris
Black Tiger

206

Ferula assa foetida
Assa foetida

208

Formica rufa

207

Flos ferri

211

Fulgora laternaria
Lantern fly

209

Fringilla Senegala
Senegal Finch

210

Fringilla maia
Cuba Finch

212

Fulica aterrima
Greater coot

213

Fulica chloropus
Moor hen

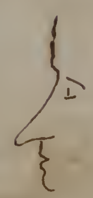
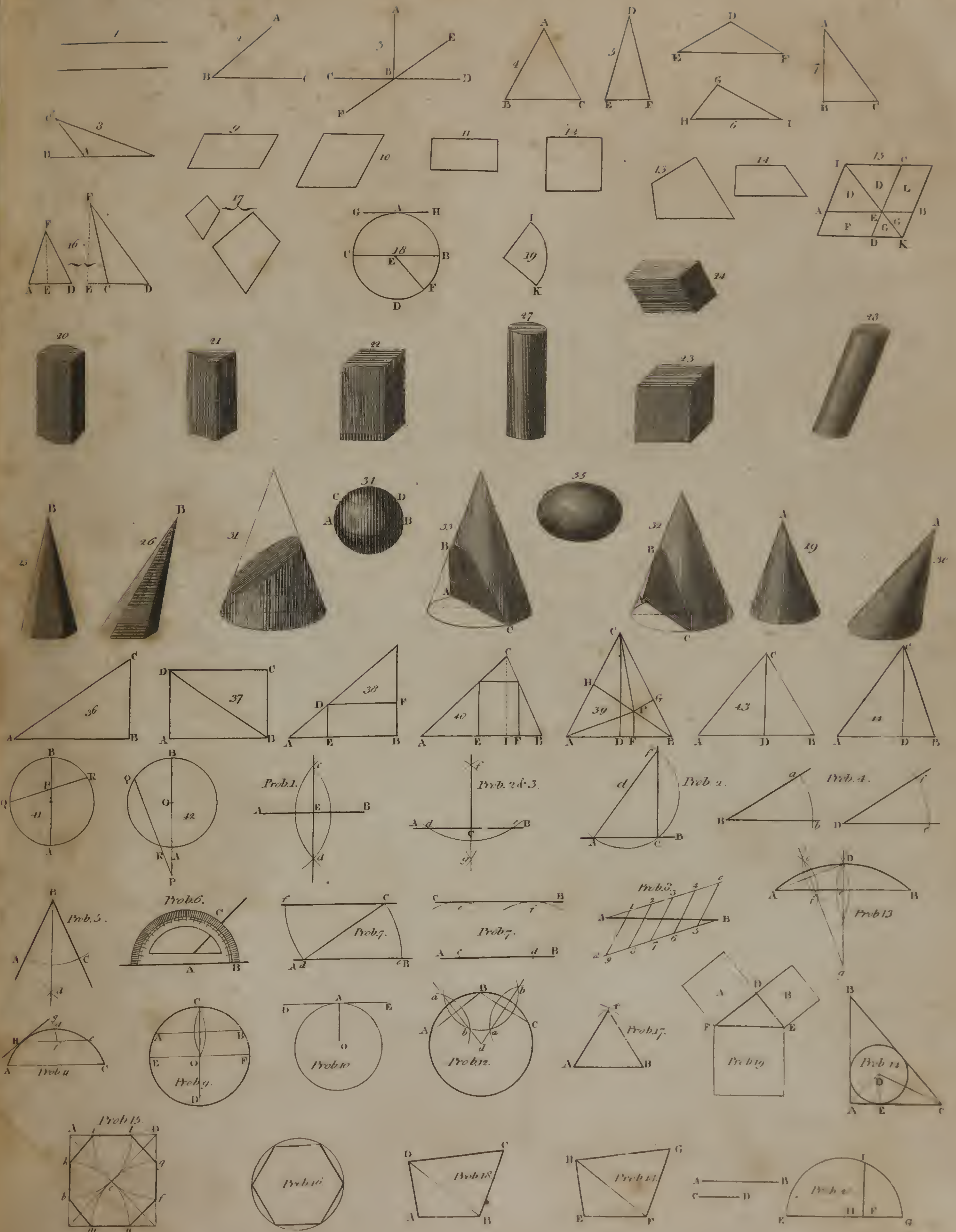
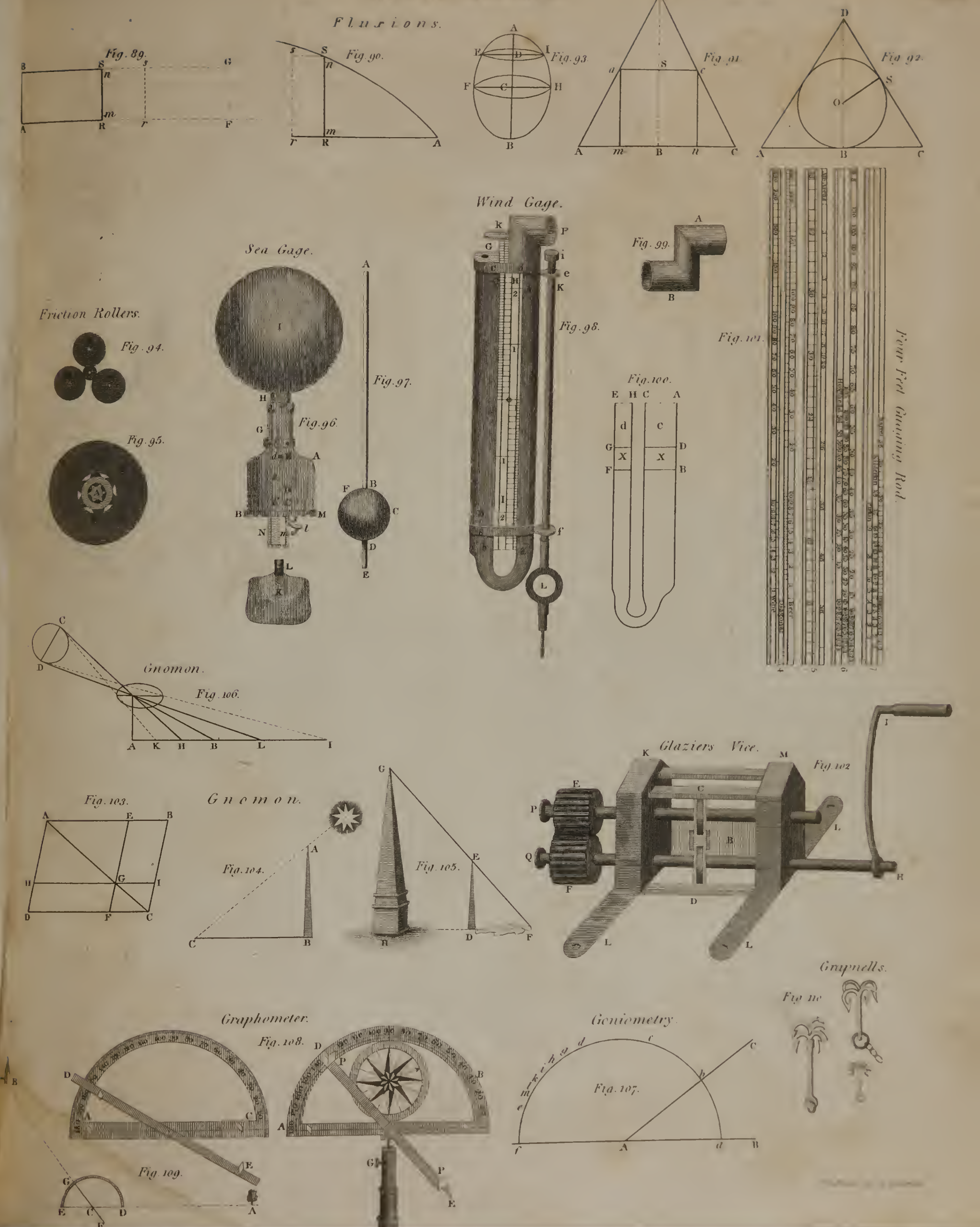


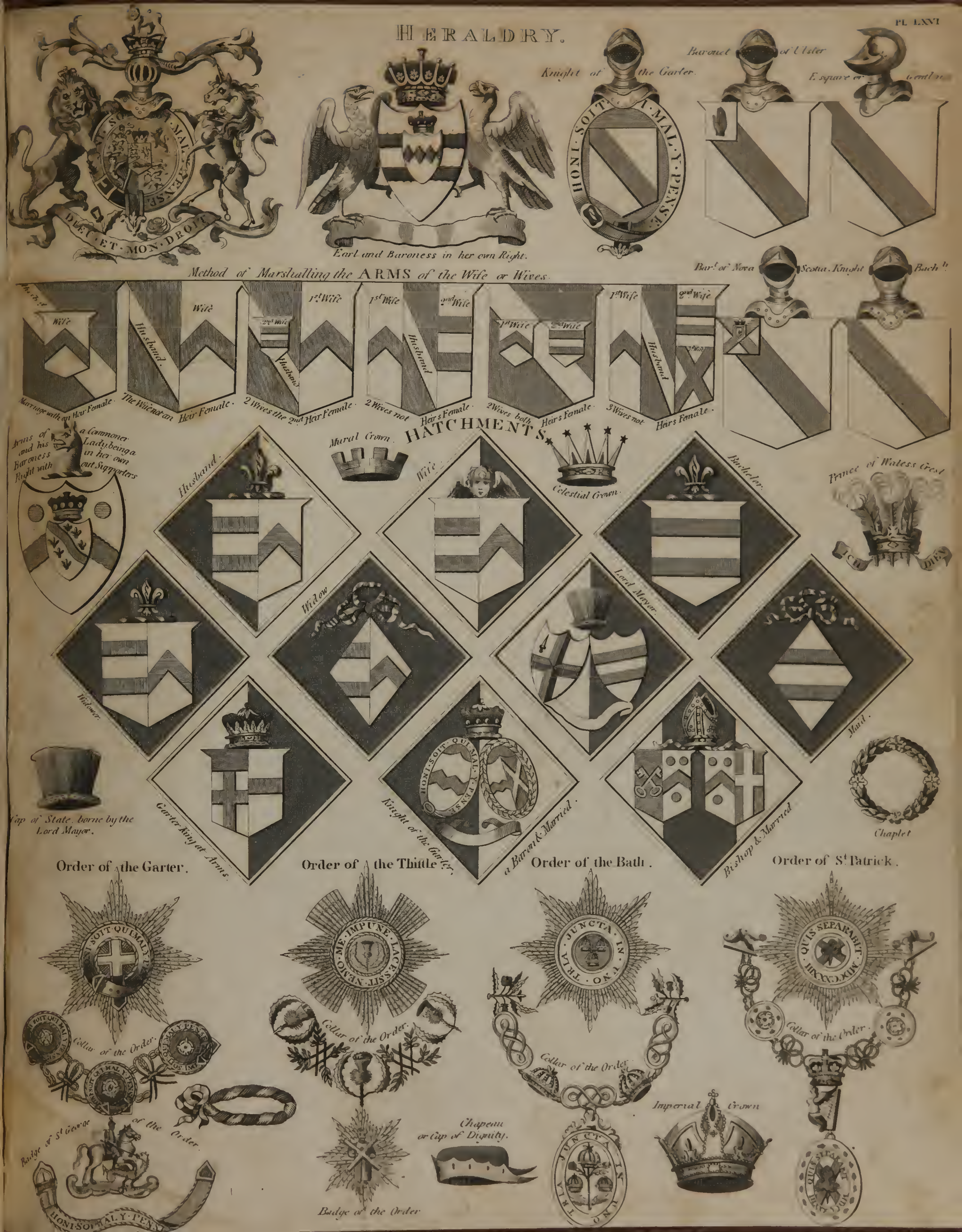

Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Fig. 5.
Fig. 6.
Fig. 7.
Fig. 8.
Fig. 9.
Fig. 10.
Fig. 11.
Fig. 12.
Fig. 13.
Fig. 14.
Fig. 15.
Fig. 16.
Fig. 17.
Fig. 18.
Fig. 19.
Fig. 20.
Fig. 21.
Fig. 22.
Fig. 23.
Fig. 24.
Fig. 25.




1
D
A
B
2
a
4
3
n
n
6
H
7
I
8
d
a
b
N
9
b
a
d
M
10
d
M
11
12
13
d
a
b
N
14
A
B
E
F
D


Flusions.
Fig. 89.
Fig. 90.
Fig. 93.
Fig. 91.
Fig. 92.
Wind Gage.
Sea Gage.
Fig. 99.
Friction Rollers.
Fig. 94.
Fig. 98.
Fig. 101.
Four Feet Guaging Rod.
Fig. 97.
Fig. 100.
Fig. 96.
Fig. 95.
Gnomon.
Fig. 106.
Glaziers Vice.
Fig. 102
Fig. 103.
Gnomon.
Fig. 104.
Fig. 105.
Grapnells.
Fig. 110
Graphometer.
Geniometry.
Fig. 108.
Fig. 107.
Fig. 109.


HERALDRY.
PL. LXV.
Partition Lines.
Engrailed.
Invecked.
Wavy.
Nebule.
Inbattled.
Ragulé.
Indented.
Dancette.
Dove Tail.
Roundels &c.
Plate.
Torteaux.
Hurt.
Pellet.
Pomey.
Golpe.
Increscent.
Decrescent.
Rose.
Annulet.
Star.
Trefoil.
Quarterfoil.
Cinquefoil.
Lozenge.
Billet.
Fountain.
Guttee.
Batcheler.
Married Man.
Heiress.
Maid.
Quarterly.
Widow.
Knight of the Garter and his Lady.
Commoner and his Lady.
Papal Crown.
Archbishop.
Bishop.
Colours.
Or. Gold
Argent White
Gules. Red
Azure. Blue
Sable. Black
Vert. Green
Purpure. Purple
Ermine.
Ermines.
Erminois.
Vair.
Potent.
Charges.
Rampant.
Rampant Gardant
Ramp.t Regardant
Passant.
Sejant.
Saliant.
Couchant.
Passant Gardant
Couped.
Erased.
Demi.
Dormant.
King.
Nobility.
Knight.
Esquire.
Close.
Rising.
Displayed.
Volant.
Tripping.
Courant.
at Gaze.
Lodged.
Inverted.
Erect.
Hauriant.
Naiant.
Cockatrice
Wyvern.
Dragon.
Tyger.
Checky.
Gyrony.
Paly.
Barry.
Points of the Escutcheon.
A Dexter Chief
B Middle Chief
C Sinister Chief
D Honor Point.
E Fess Point
F Nombril Point
G Dexter Base
H Middle Base
I Sinister Base
A B C D E F G H I
Distinctions of Houses.
1 2 First House 5 6
1 2 Second House 5 6
1 2 Third House 5 6
1 2 Fourth House 5 6
1 2 Fifth House 5 6
1 2 Sixth House 5 6
Fess.
Chevron.
Bend.
Pale.
Chief.
Cross.
Saltire.
Bend Sinister
Quarter.
Canton.
Pile.
Flanche.
Flory.
Moline.
Patte.
Lozenge
Mullet
Gutte or Drops.
Kings Crown & Helmet.
Prince of Wales.
Coronet of Princes of the Blood Royal
Duke


HERALDRY.
Pl. LXVI.
DIEU ET MON DROIT
Earl and Baroness in her own Right.
Knight of the Garter.
Baronet of Ulster
Esquire or Gentleman
Method of Marshalling the ARMS of the Wife or Wives.
Bar.t of Nova Scotia, Knight Bach.r
Wife
Husband.
2nd Wife
1st Wife
Marriage with an Heir Female.
The Wife not an Heir Female.
2 Wives the 2nd Heir Female.
2 Wives not Heirs Female.
2 Wives both Heirs Female.
3 Wives not Heirs Female.
HATCHMENTS.
Mural Crown.
Celestial Crown.
Arms of a Commoner and his Lady being a Baroness in her own Right with out Supporters
Husband.
Wife.
Bachelor.
Prince of Wales's Crest
ICH DIEN
Widow.
Lord Mayor.
Widower.
Maid.
Cap of State, borne by the Lord Mayor.
Garter King at Arms.
Knight of the Garter.
a Baron & Married.
Bishop & Married.
Chaplet
HONI SOIT QUI MAL Y PENSE
Order of the Garter.
Order of the Thistle.
Order of the Bath.
Order of St. Patrick.
NEMO ME IMPUNE LACESSIT
TRIA JUNCTA IN UNO
QUIS SEPARABIT MDCCLXXXIII
Collar of the Order.
Badge of St George of the Order.
Chapeau or Cap of Dignity.
Badge of the Order
Imperial Crown

Glareola austriaca

214

Gryllus griseus

215

Gryllus stridulus

216

Guaiacum officinale

217

Gymnotus electricus
Electrical eel

218

Hæmatopus ostralegus
Sea-pie

219

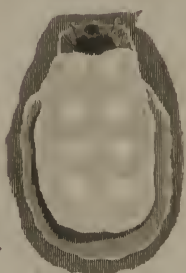
Hedysarum gyrans

222

Helix sepium

223

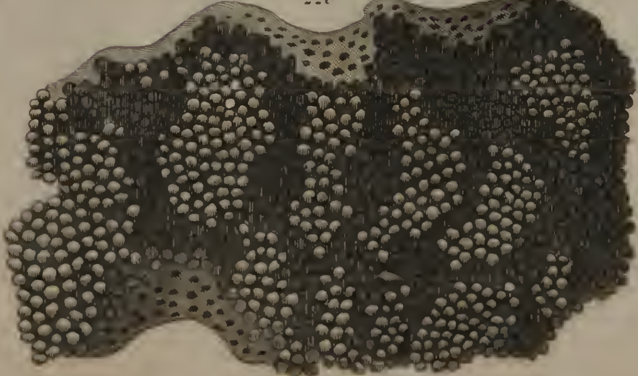
Haliotis tuberculata



221

Hæmatites urceolatus

220



Hemerobius perla

224

Hippobosca equina

225

GRASSES

1. Poa pratensis (Smooth stalk'd meadow Grass)
2. Festuca duriuscula (Hard fescue Grass)
3. Festuca pratensis (Meadow fescue Grass)

4. Lolium perenne (Rye Grass)
5. Alopecurus pratensis (Meadow foxtail Grass)
6. Festuca ovina (Sheeps fescue Grass)
7. Poa angustifolia (Narrow leav'd meadow Grass)

GRASSES &c.

8

Poa trivialis
Rough stalk meadow Grass

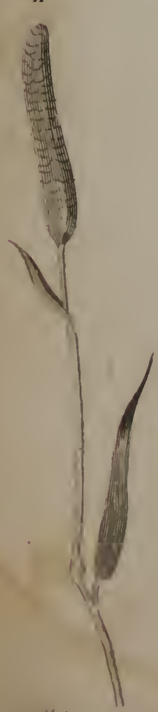
9

Poa palustris
Marsh meadow Grass

10

Cynosurus cristatus
Crested dog's tail Grass

11

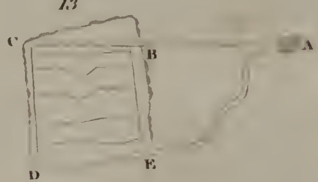


Phleum [illegible]

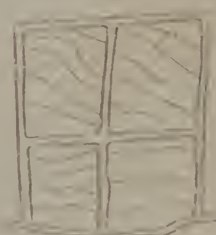
12

Anth. odoratum

13



14



Irrigation

15

Somersetshire Plough

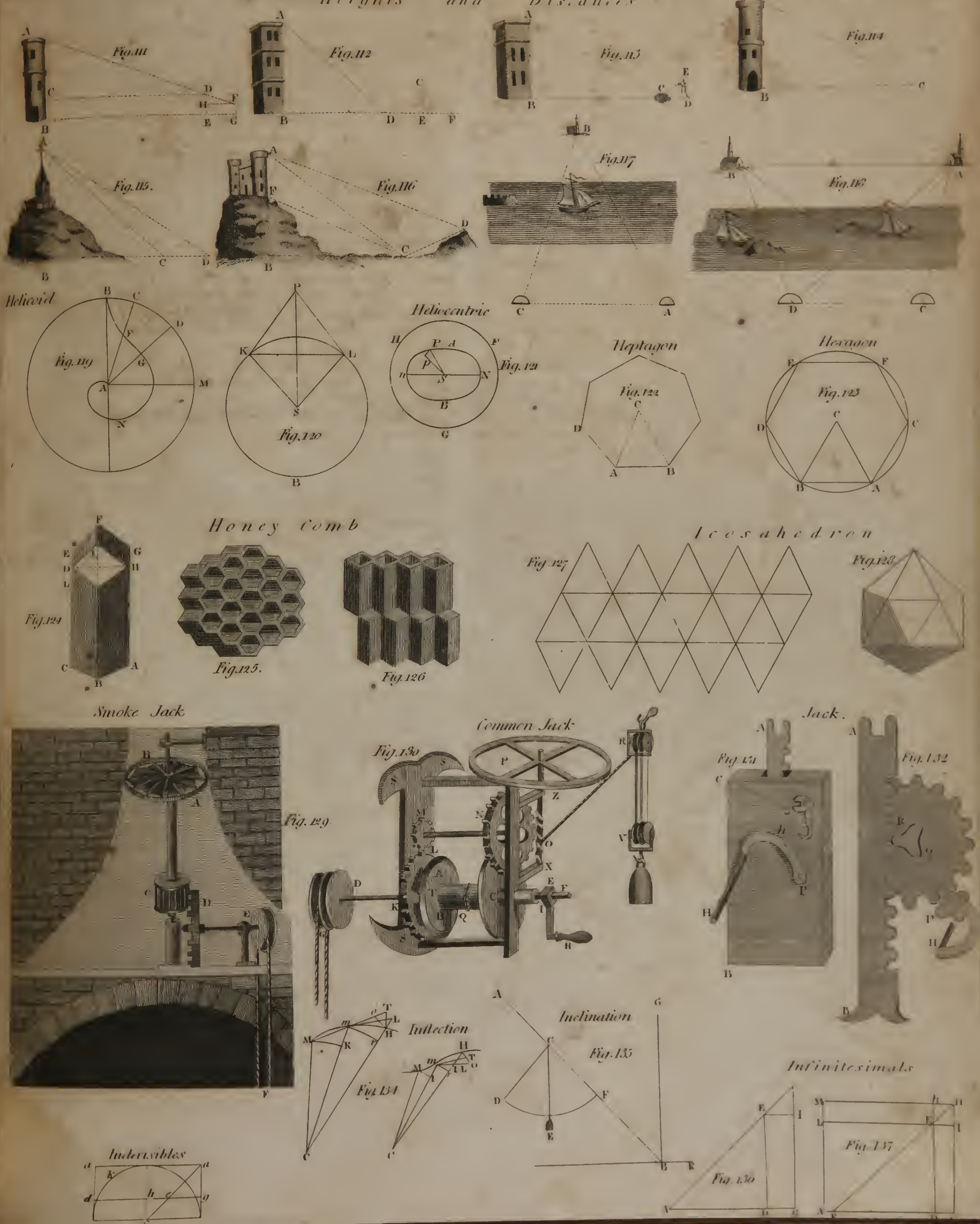
Norfolk Plough

Double furrow Plough

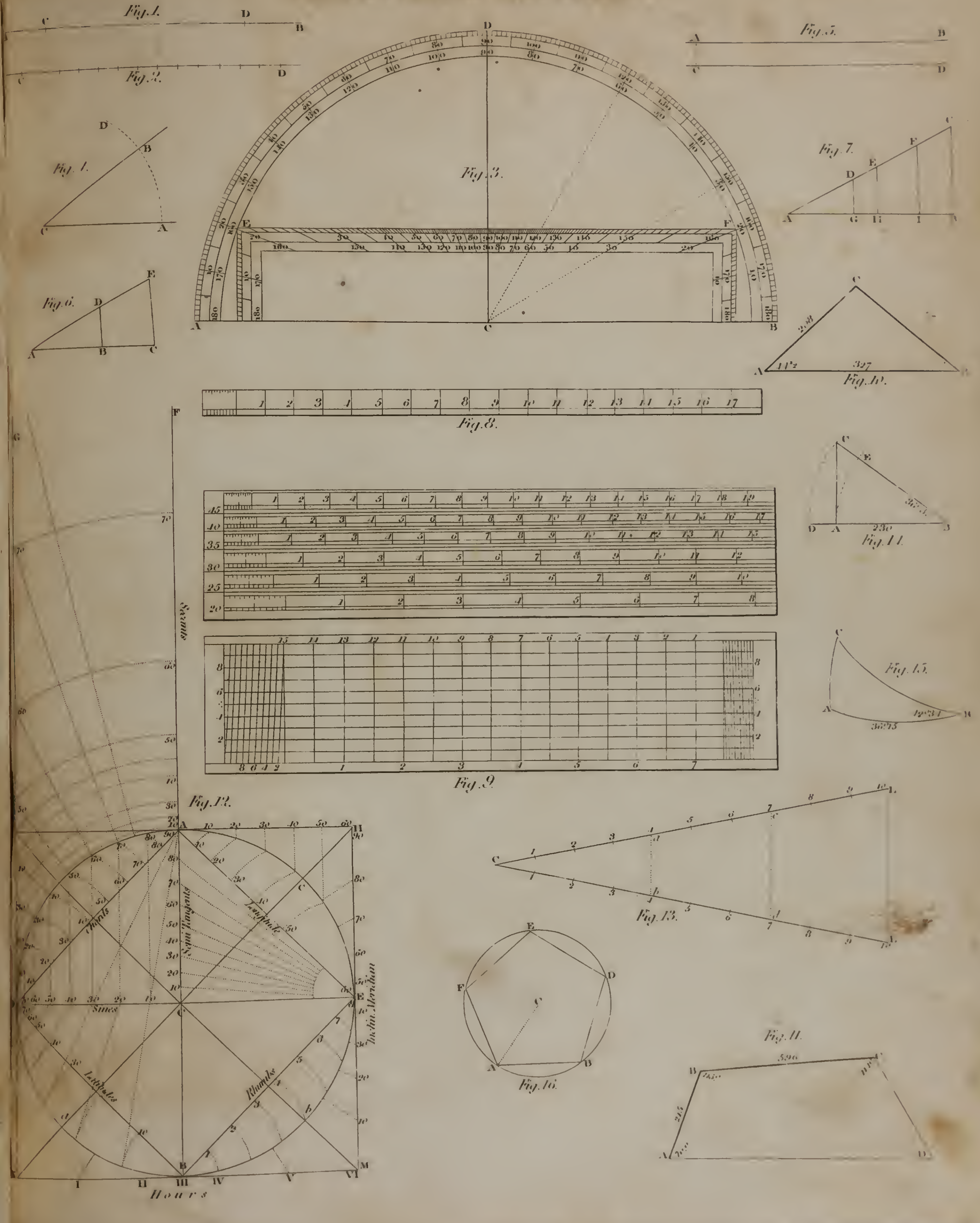
Horne's sowing Machine


Beaumes Areometer
Higher Scale
Very Wet
Moist
Moderately
Middle State
Dry
Greatest Drought
Very Dry

Heights and Distances

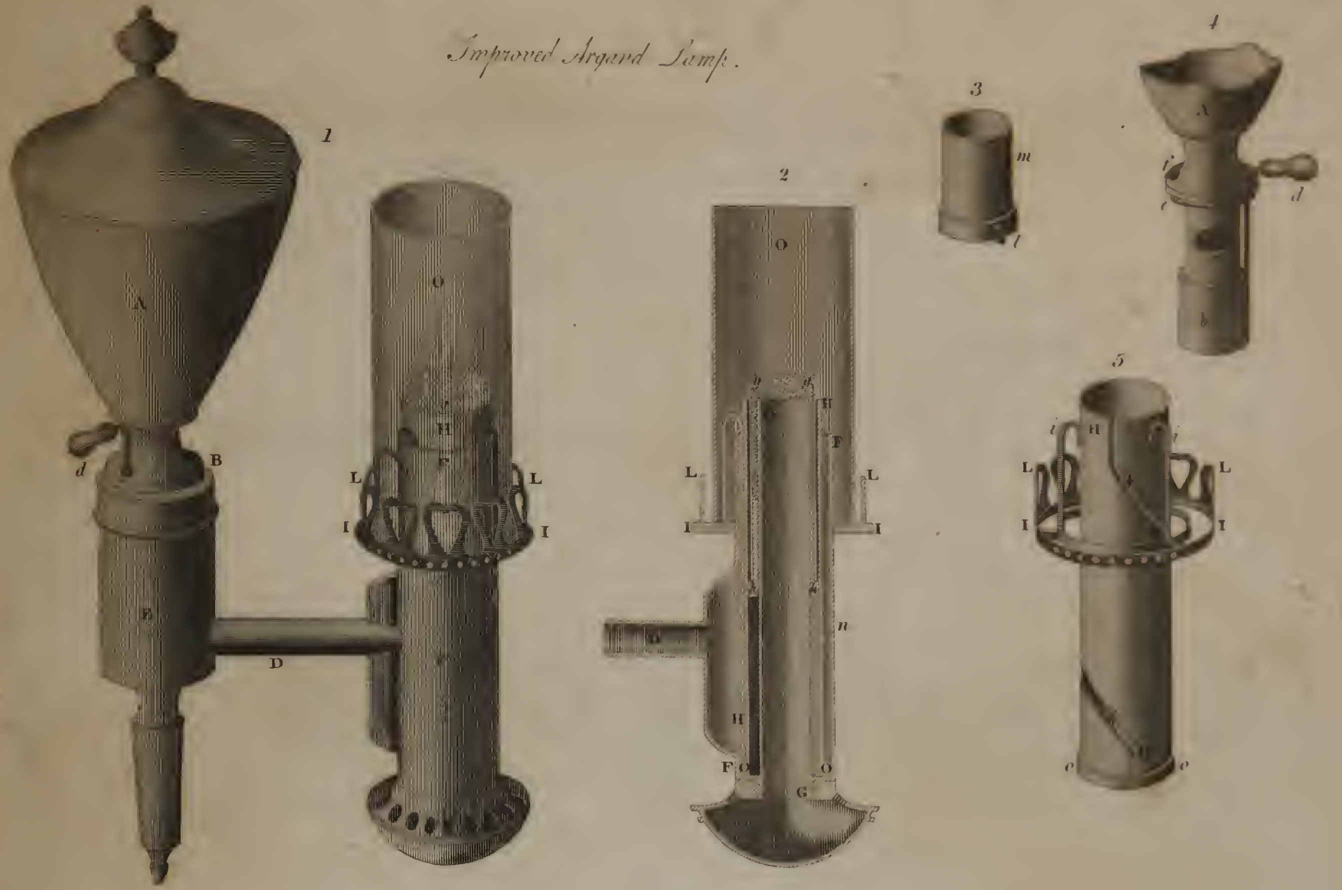


MATHEMATICAL INSTRUMENTS.

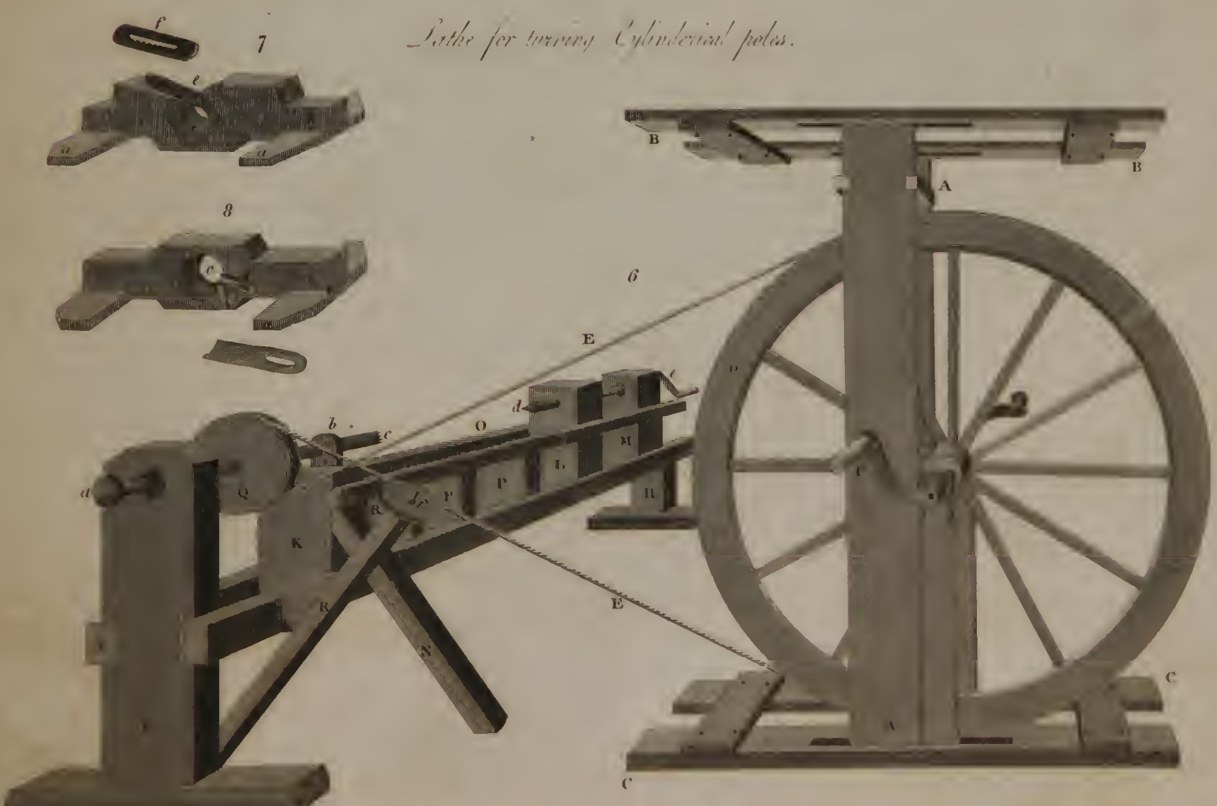



227
Hirundo apus
Swift
228
Hirundo esculenta
Esculent Swallow
229
Hispa atra
230
Hyrax Syriacus
231
Hystrix cristata
Porcupine
226
Hippopotamus amphibius
River Horse
232
Ichneumon manifestator
233
Ichneumon jaculator
234
Julus terrestris
236
Lacerta calotes
Asiatic Guana
235
Lacerta bullaris
237

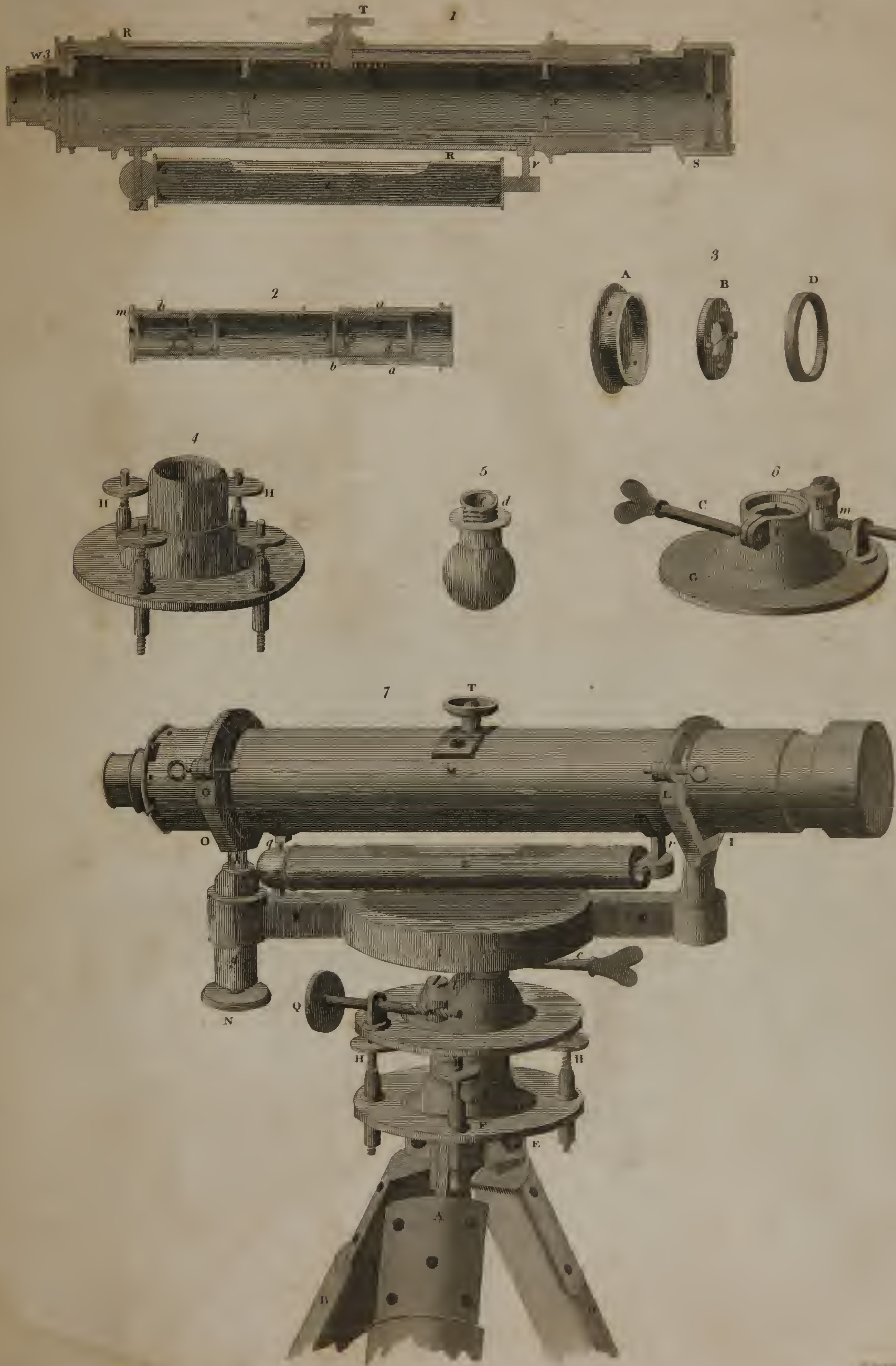
Improved Argand Lamp.



Lathe for turning Cylindrical poles.



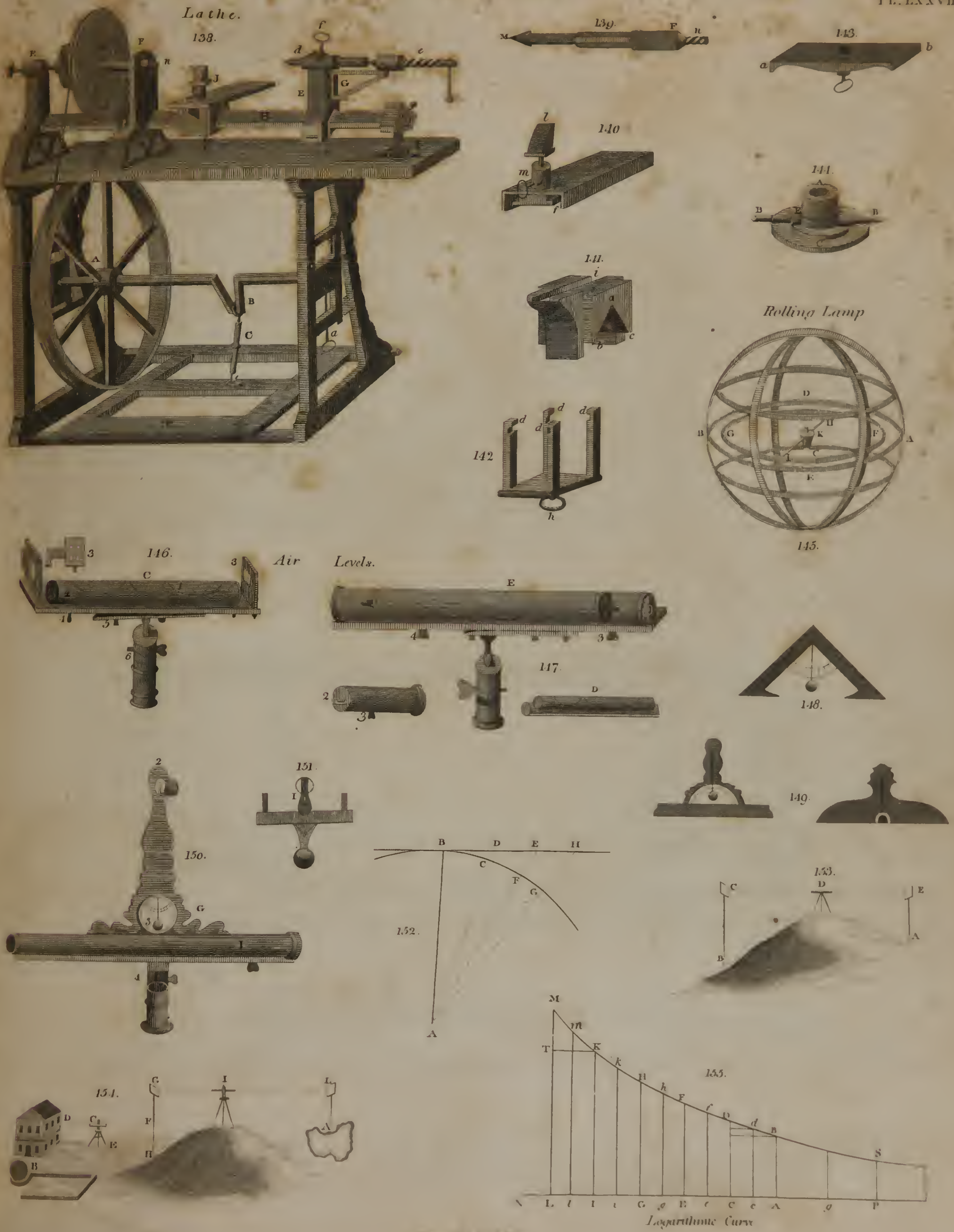
Spirit LEVEL.




238
239
Lampyris Italica
Lampyris sanguinea
240
Lanius varius
White shouldered Shrike
241
Lapis calcedonius
242
Larus cinerarius
Red legged Gull
243
Lantana aculeata
244
Laurus camphora
Camphor Tree
245
246
Lepus alpinus
247
Lepus ogotona
248
Lepas anatifera
Duck bernacle
248
250
Libellula forcipata
251
Libellula flaveola

MISCELLANIES.

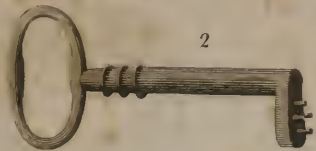
PL. LXXVIII.



Mr. Stansbury's patent Lock.

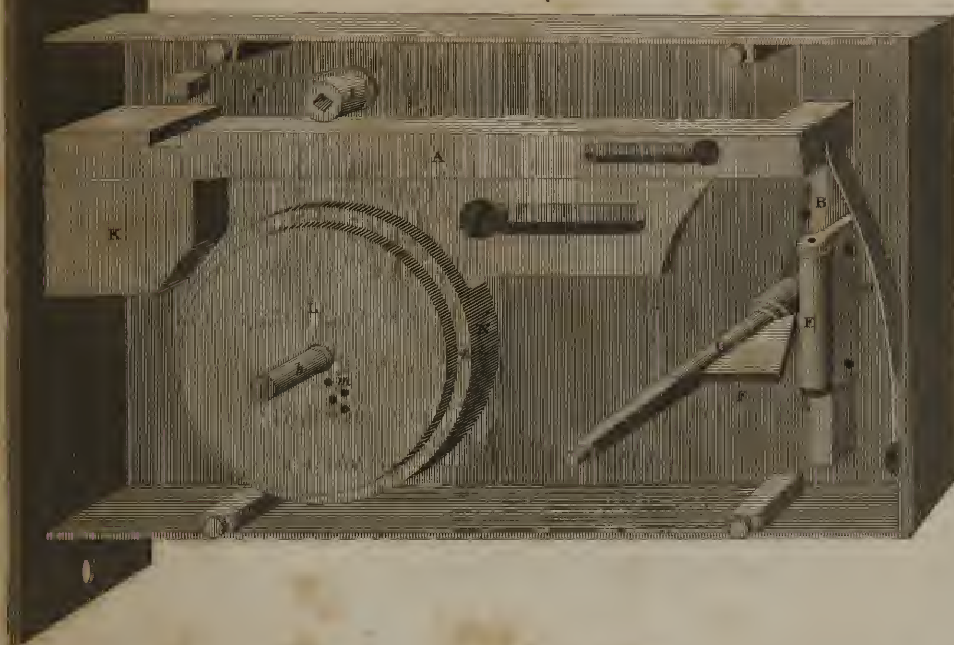
1

2



3

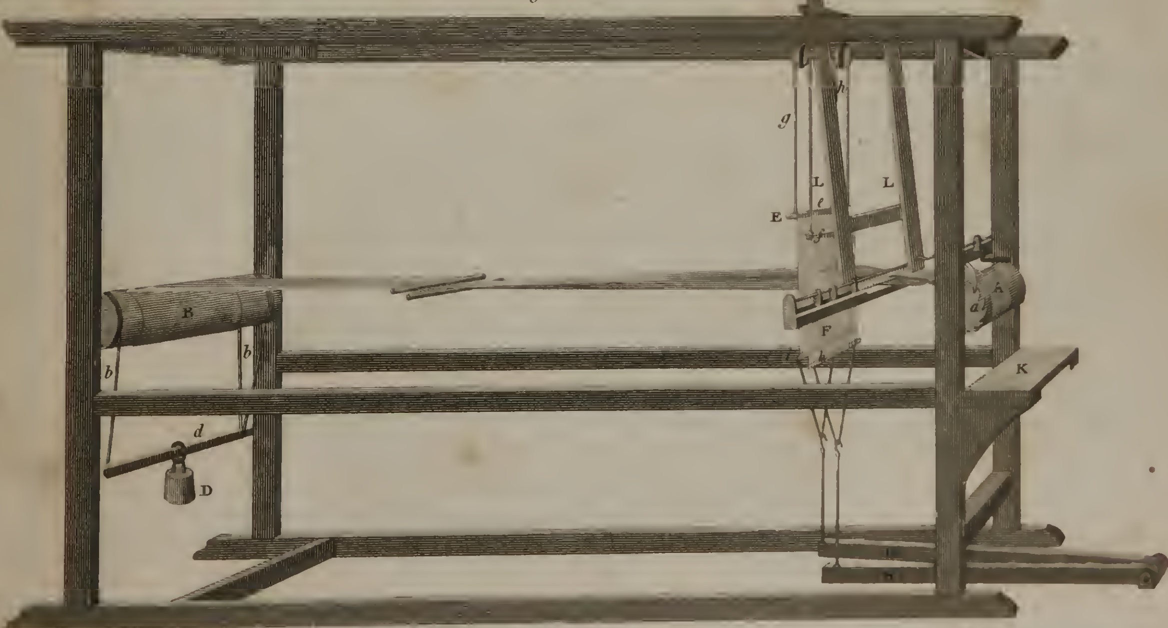
4



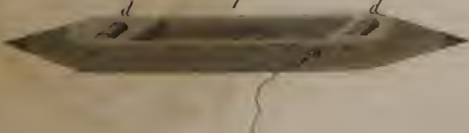
5

Loom

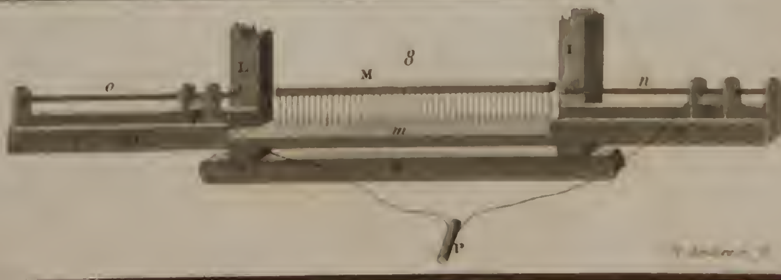
6



7



8



MAGNETISM.

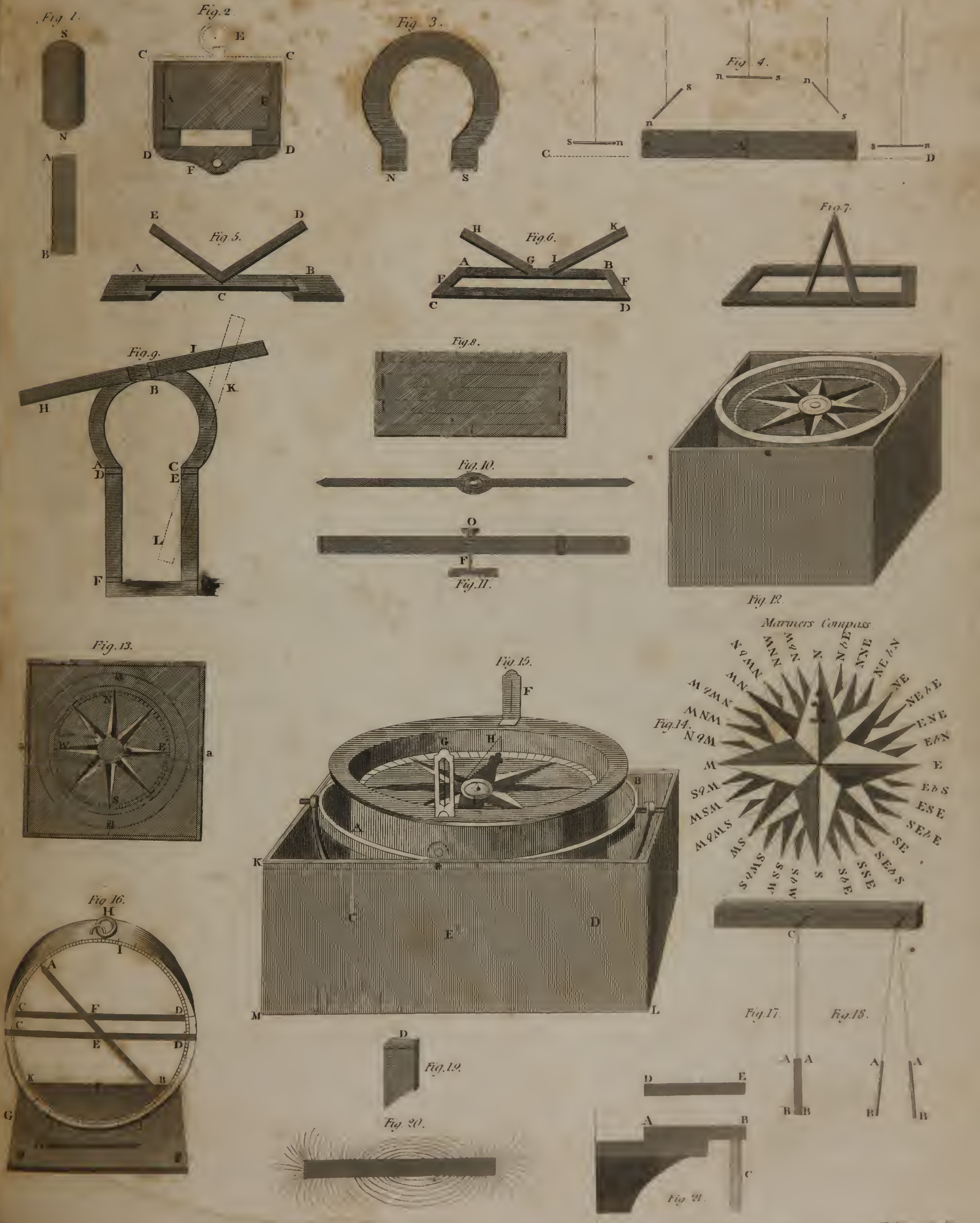


Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Fig. 5.
Fig. 6.
Fig. 7.
Fig. 8.
Fig. 9.
Fig. 10.
Fig. 11.
Fig. 12.
Mariners Compass.
Fig. 13.
Fig. 14.
Fig. 15.
Fig. 16.
Fig. 17.
Fig. 18.
Fig. 19.
Fig. 20.
Fig. 21.

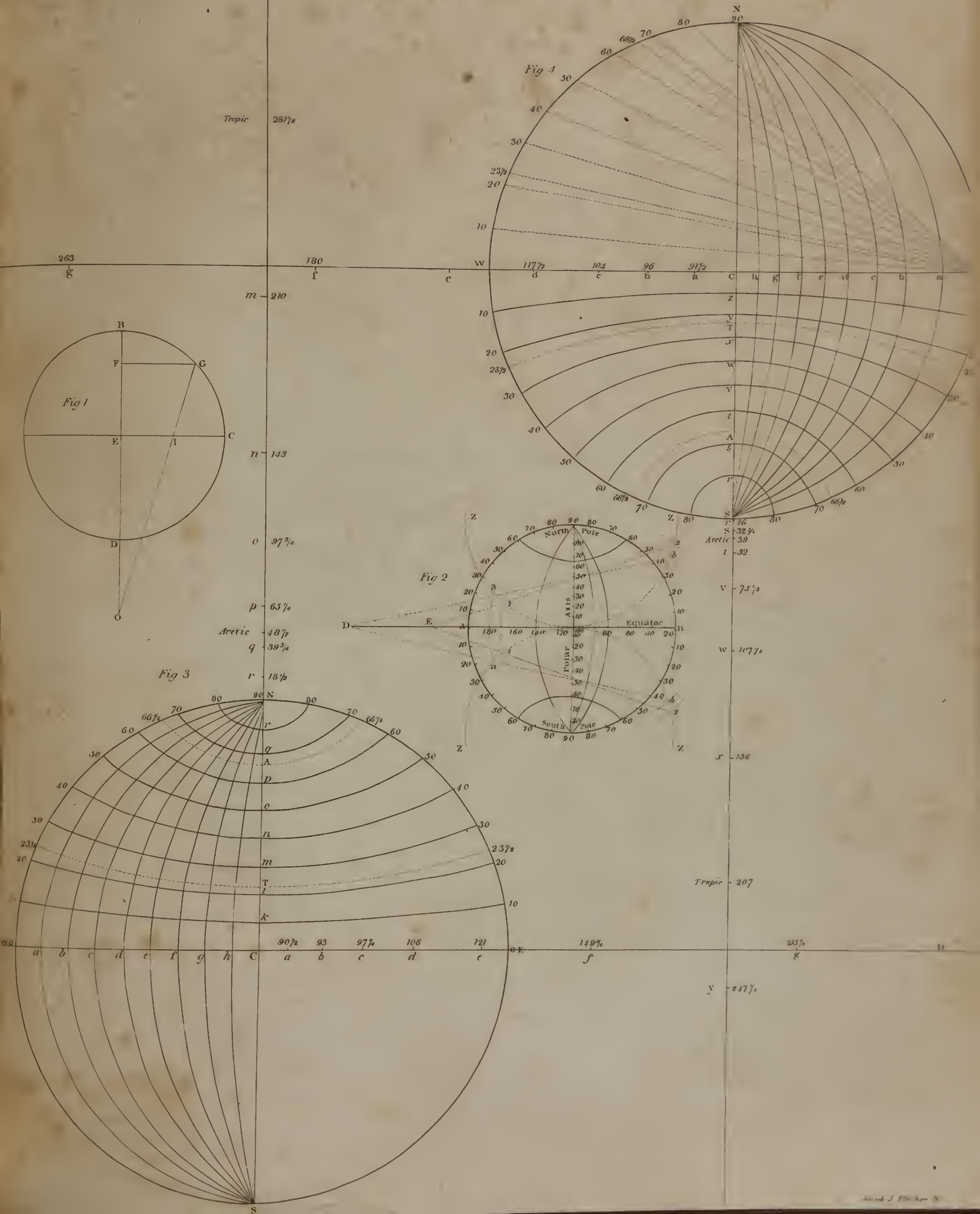


Fig 1
Fig 2
Fig 3
Fig 4
Tropic
Arctic
North Pole
South Pole
Equator
Axis
Polar
Tropic 281½
Arctic 48⅐
Tropic 207

Fig. 5.

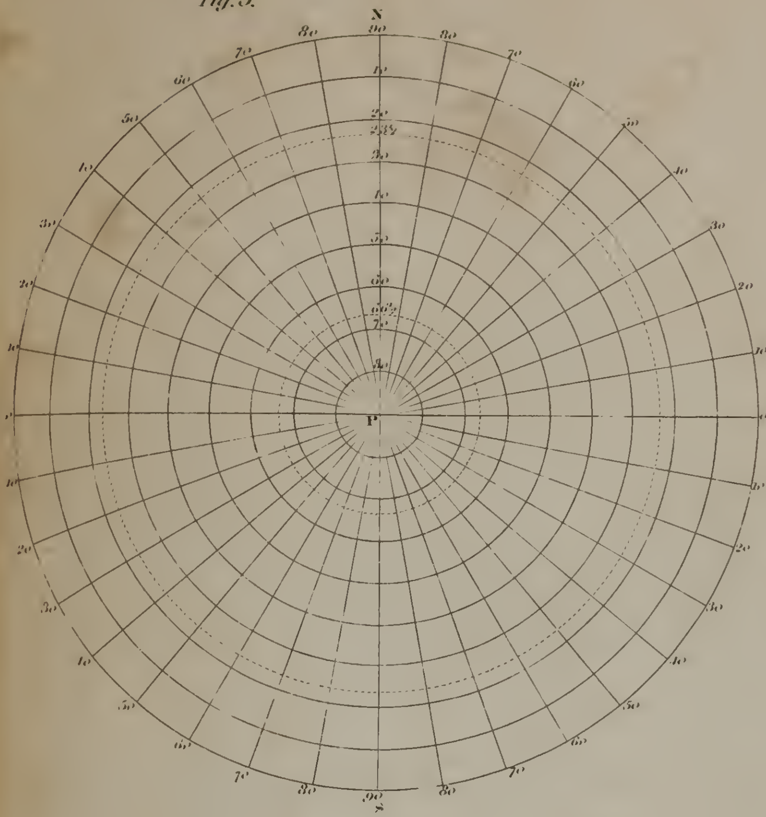


Fig. 6.

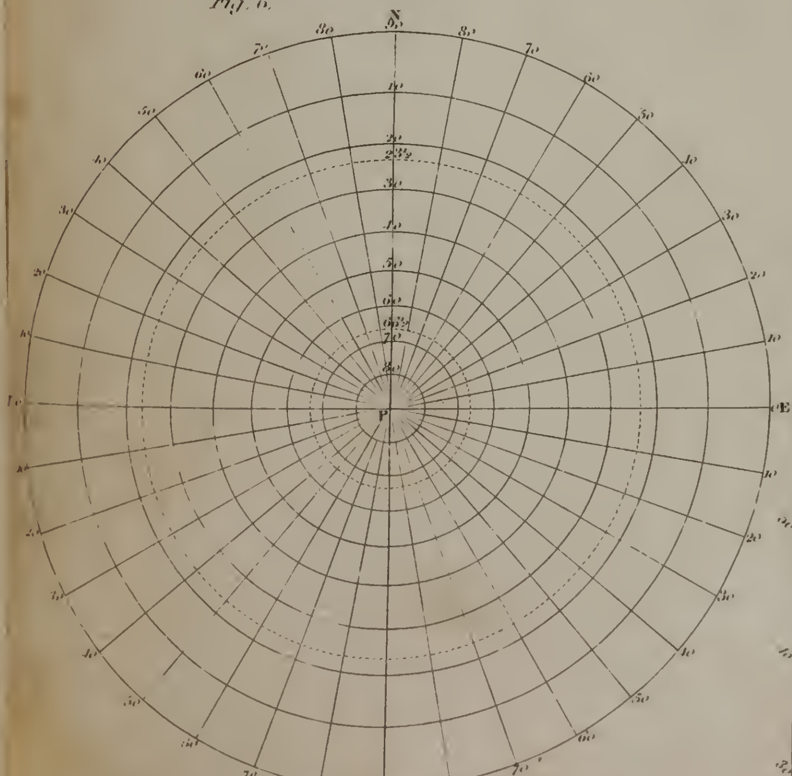
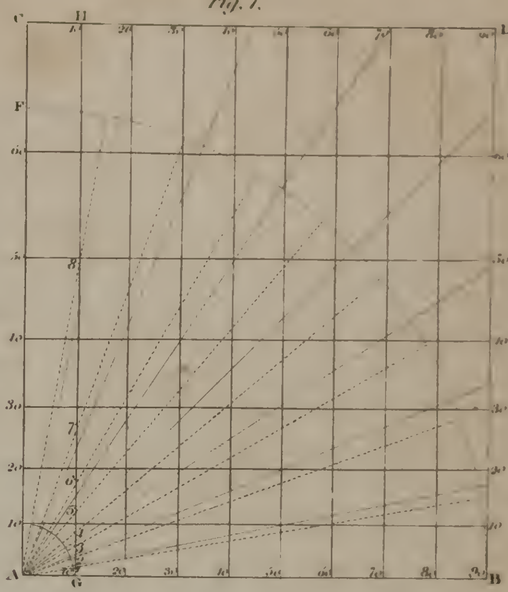


Fig. 7.



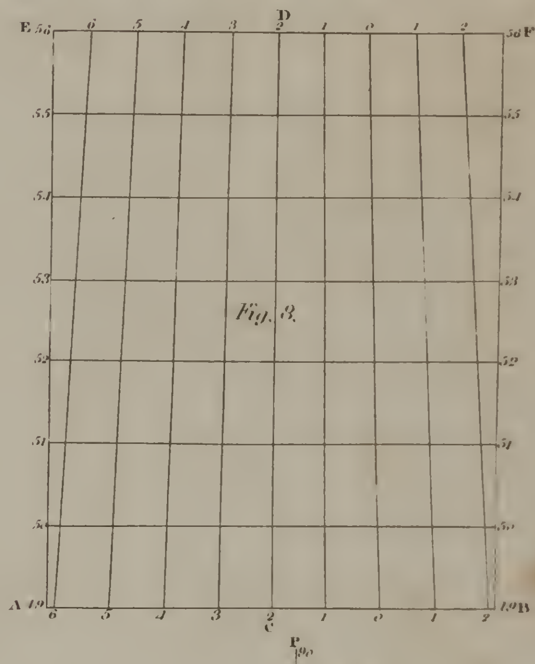


Fig. 8.

Fig. 9.

Fig. 10.

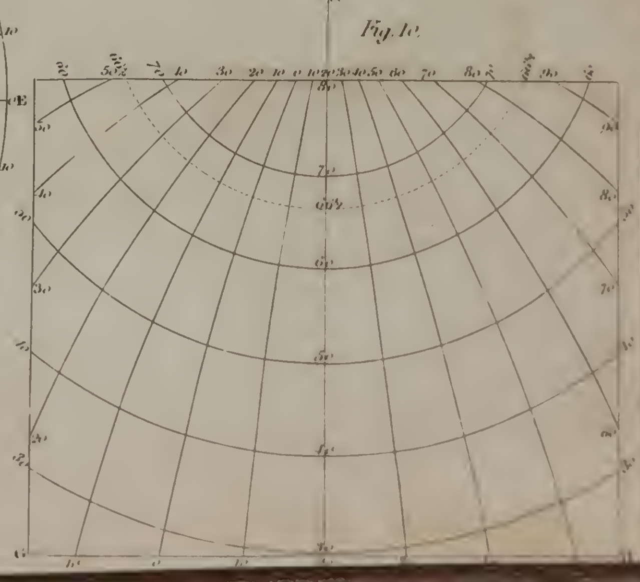


Fig. 11.

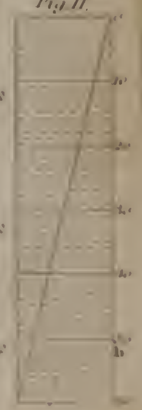
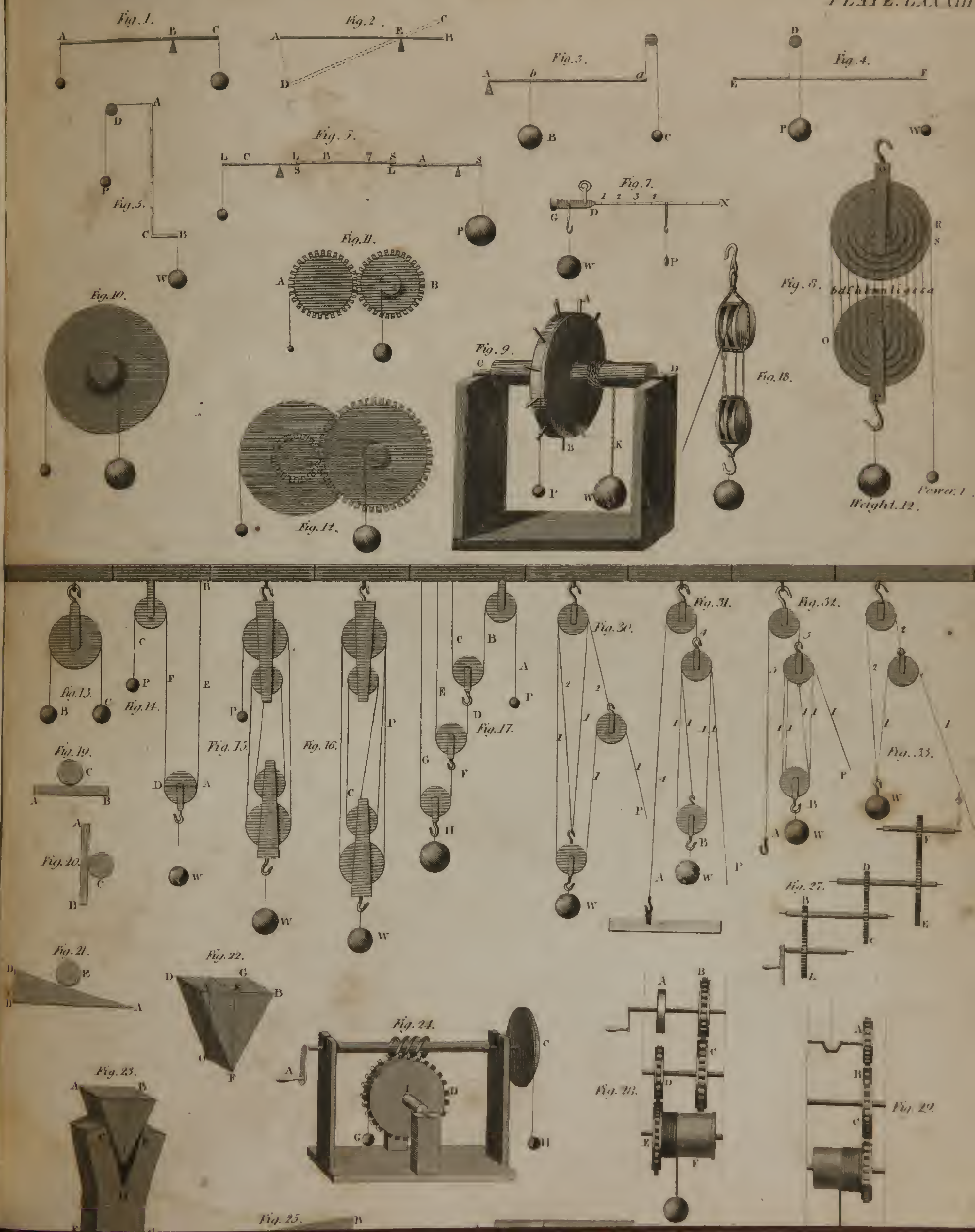


PLATE. LXXVIII




Lobelia Syphillitica
252
Loxia oryxivora
Java Grosbeak
253
254
Loxia pensilis
Pensile Grosbeak
with its nest
Labricus marinus
255
Madrepora cespitosa
256
Mantis pentadactyla
Short tailed Manis
258
Madrepora lactuca
257
Mantis religiosa
259
Melyris viridis.
264
Maranta galanga
Galangal
260
Meloe vesicatorius
Spanish Fly
263
Meleagris satyra
Horned Turkey
261
Medusa Pelagica
262


1
2
3
4
5
6
12
8
9
10
11
13
7
17
18
22
14
16
19
20
24
15
23
26
27
25
27
28
29
30
31
32
33
34
35

267

Millepora polymorpha

266

Millepora cellulosa

265

Mergus cucullatus

268

Monoculus oculatus

269

Monodon

270

Moschus moschiferus
Thibet Musk

271

Motacilla sylvia
White throat

272

Mugil cephalus

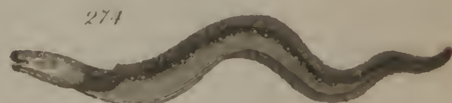
273

Mullus barbatus

275

Muræna ophis
Spotted sea serpent

274

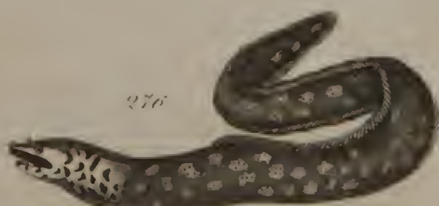


Muræna conger
Conger eel

278

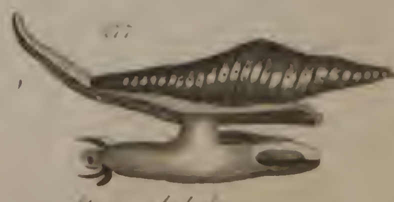
Murex brandaris

276



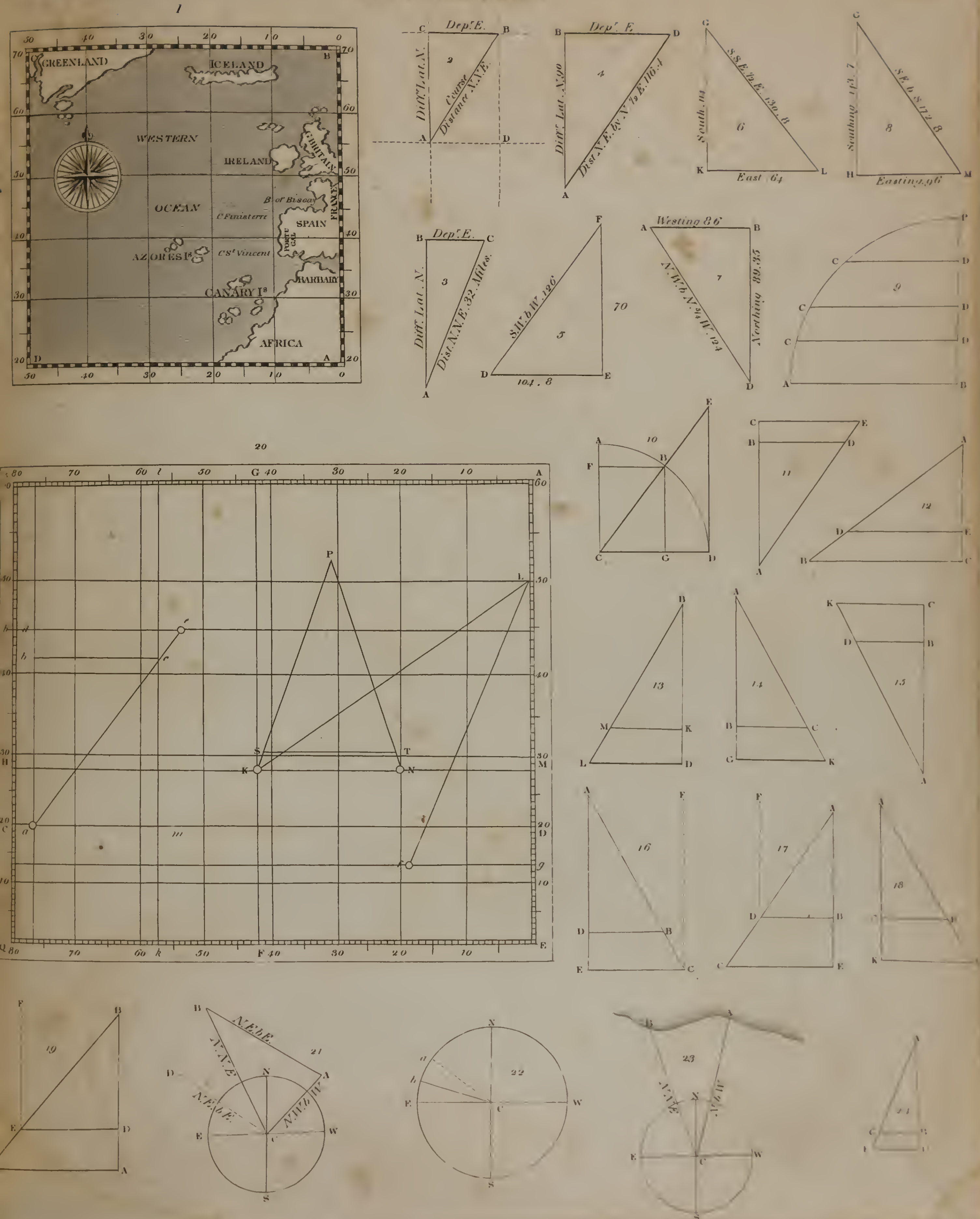
Muræna helena

277

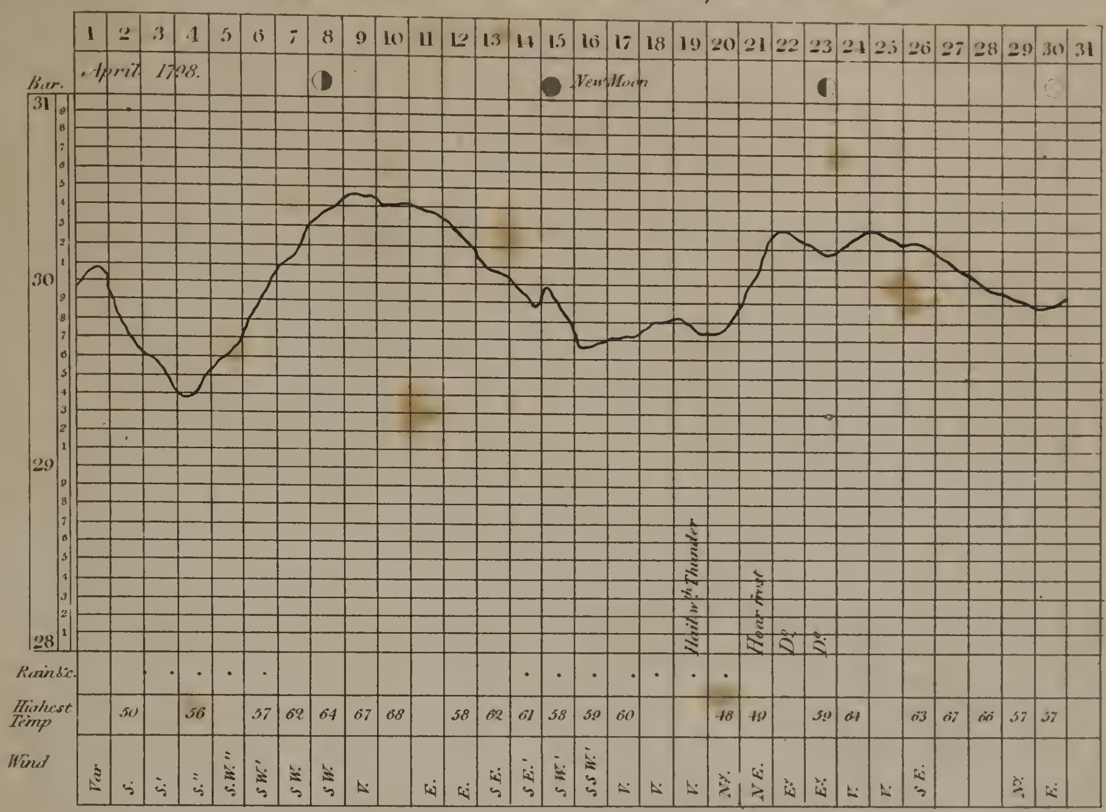


Murex babylonica


Mus zibethicus
Musk Rat
279
Mus lemmus
280
Muscicapa rubricollis
283
Muscicapa flabellifera
Fan tailed Fly catcher
281
uscicapa malachura
282
Mustela furo
284
Musca filata
285
Mustela erminea
Stoat
286
Mutilla belvola
287
Myrica cerifera
Candle berry myrtle
289
Mycteria Americana
288
Myrmecophaga didactyla
Least Ant eater
290
291
Myrmeleon barbarus

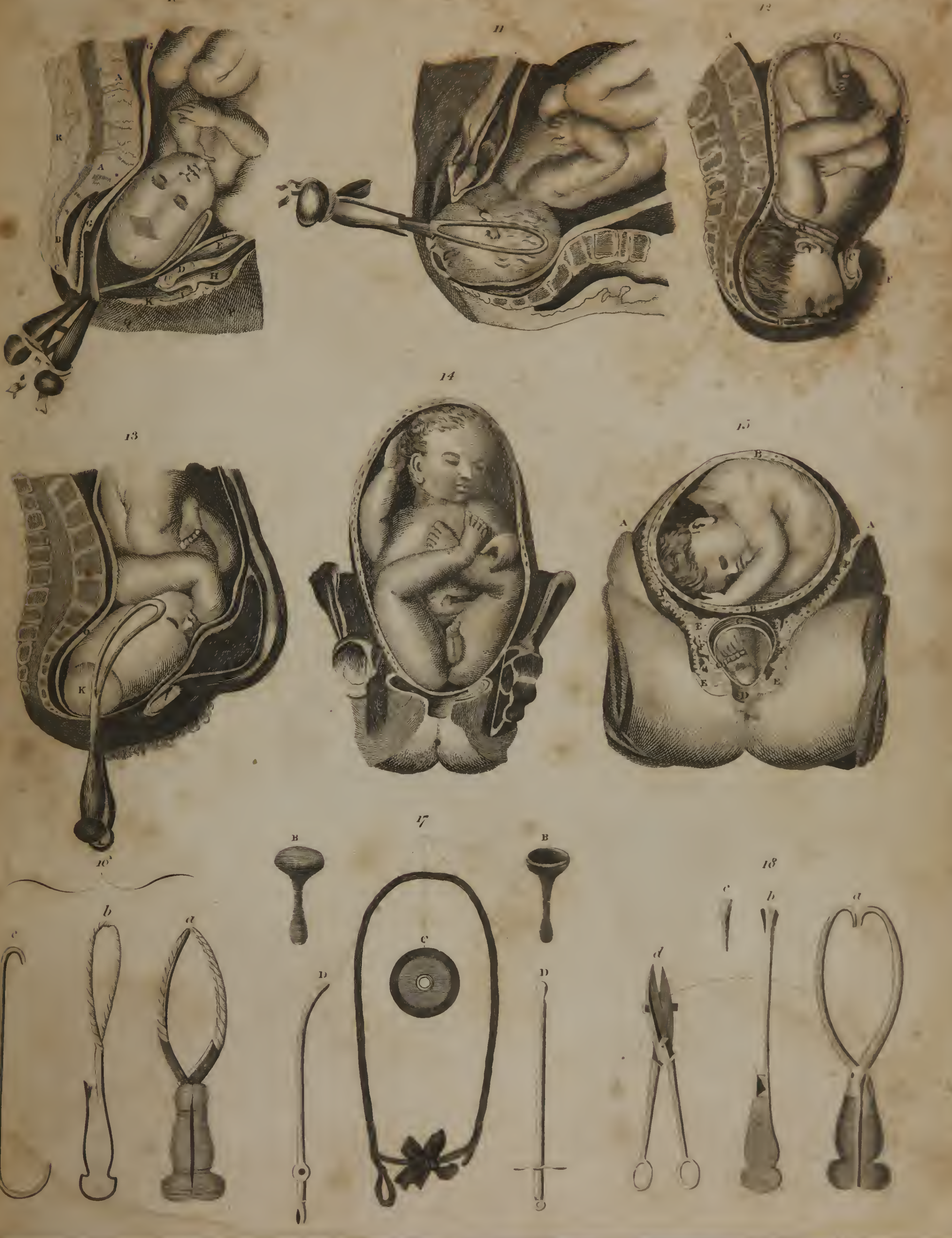

GREENLAND
ICELAND
WESTERN
IRELAND
G. BRITAIN
OCEAN
B. of Biscay
C Finisterre
FRANCE
SPAIN
PORTUGAL
AZORES Is.
C St Vincent
BARBARY
CANARY Is.
AFRICA
Dep.t E.
Diff.r Lat. N.
Course
Distance N.N.E.
Diff.r Lat. N. 90
Dist. N.E. by N. ½ E. 116.4
S.S.E. ½ E. 130.8
South 114
East 64
S.E. b S. 172.8
Southing 143.7
Easting 96
Dist. N.N.E. 32 Miles.
S.W. b W. 126
104.8
Westing 86
N.W. b N. ¾ W. 124
Northing 89.35
N.E. b E.
N.N.E.
N.W. b W.
N.N.W.

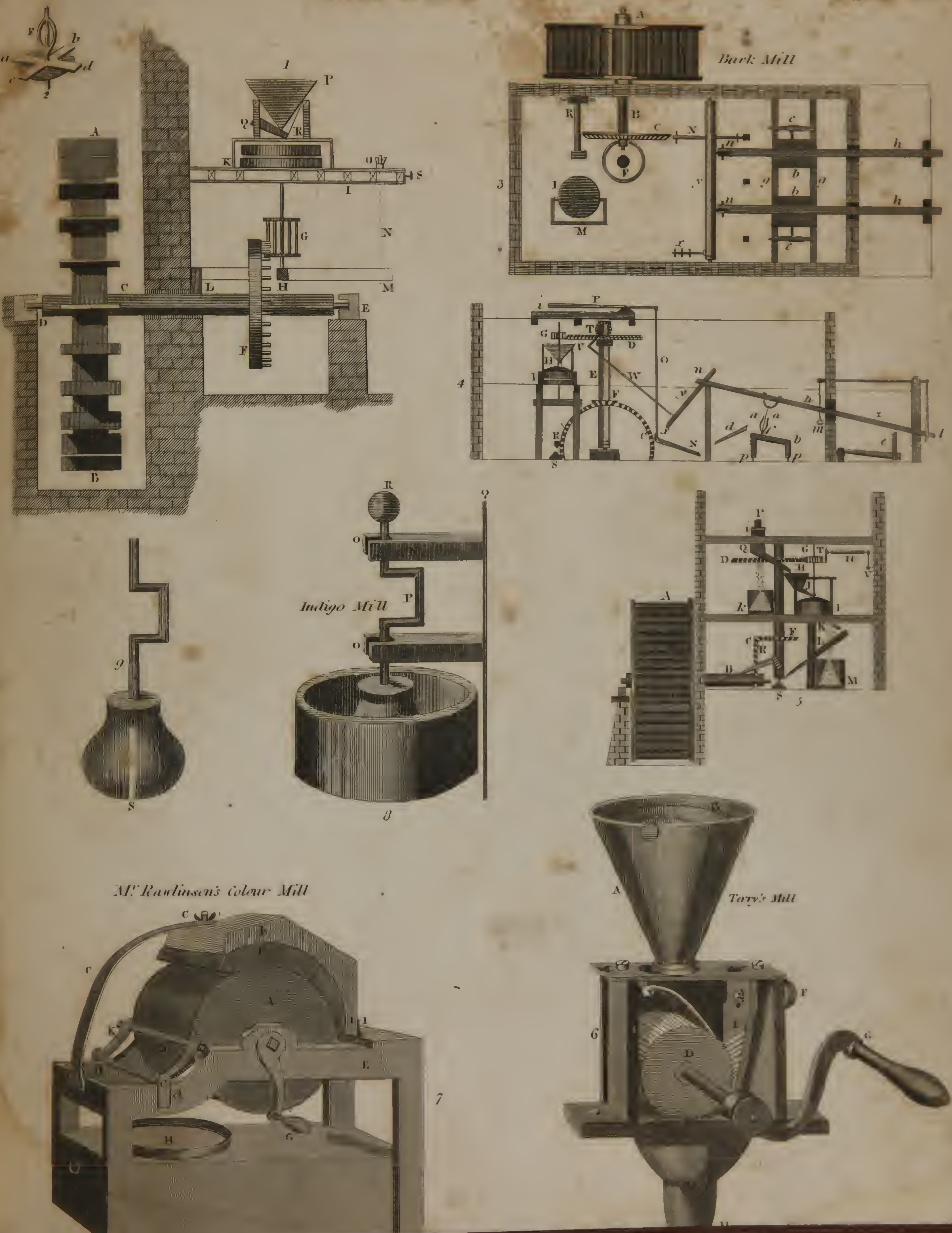
Specimen of a Register calculated to exhibit periodical Variations.

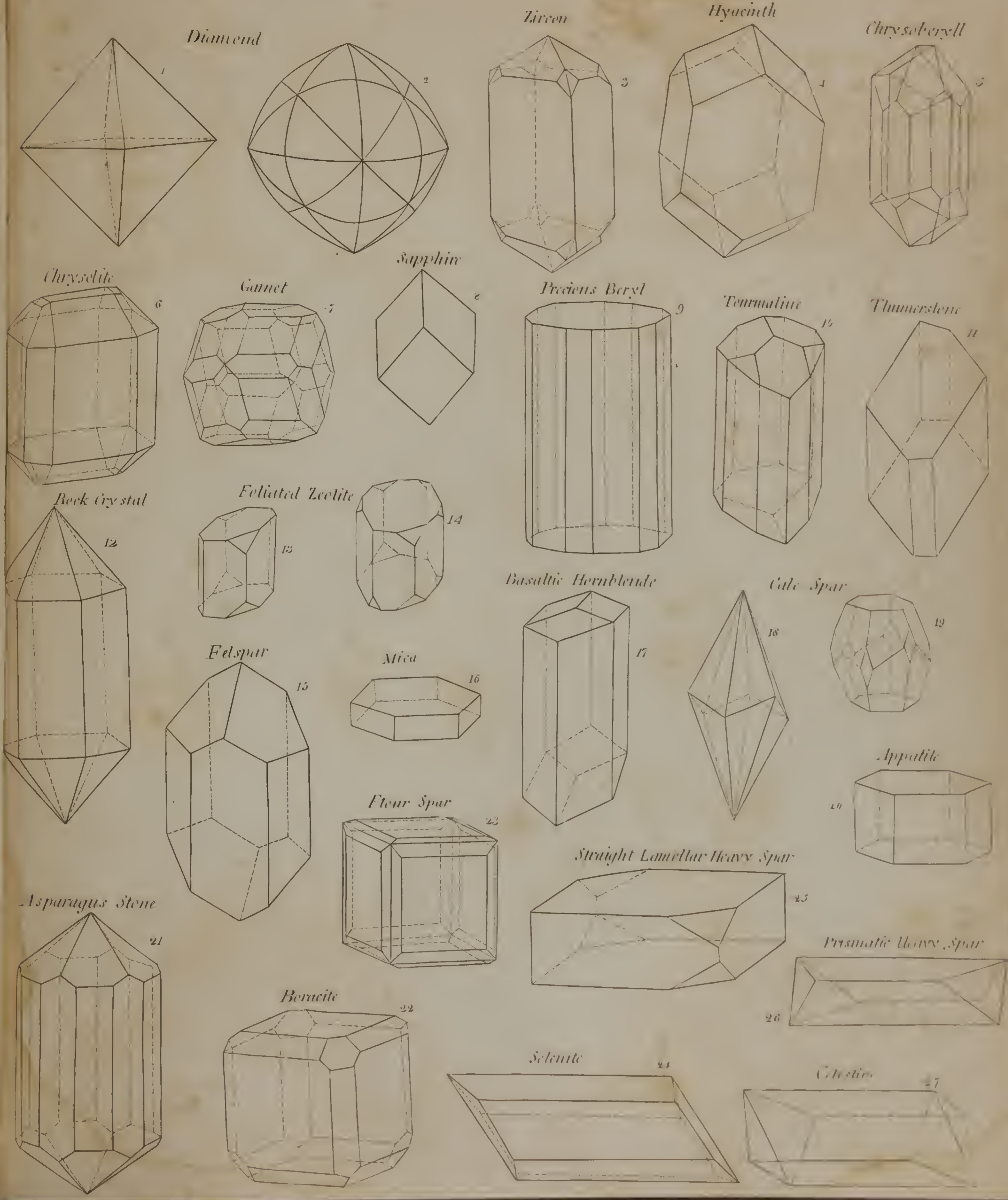


Rain is denoted by •   Strong Winds by '   Storms by "

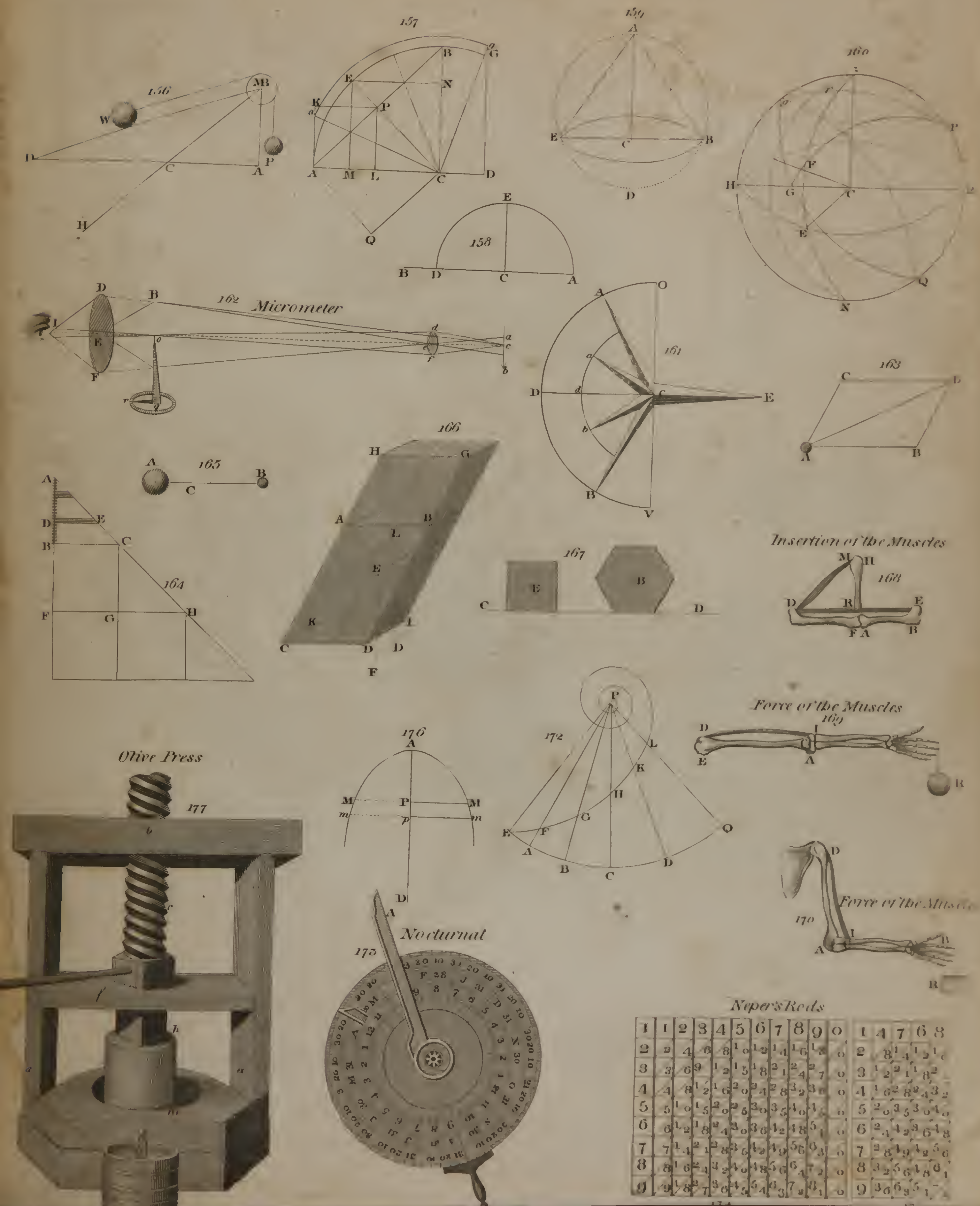

1
2
3
4
5
6
7
8
9


10
11
12
13
14
15
16
17
18

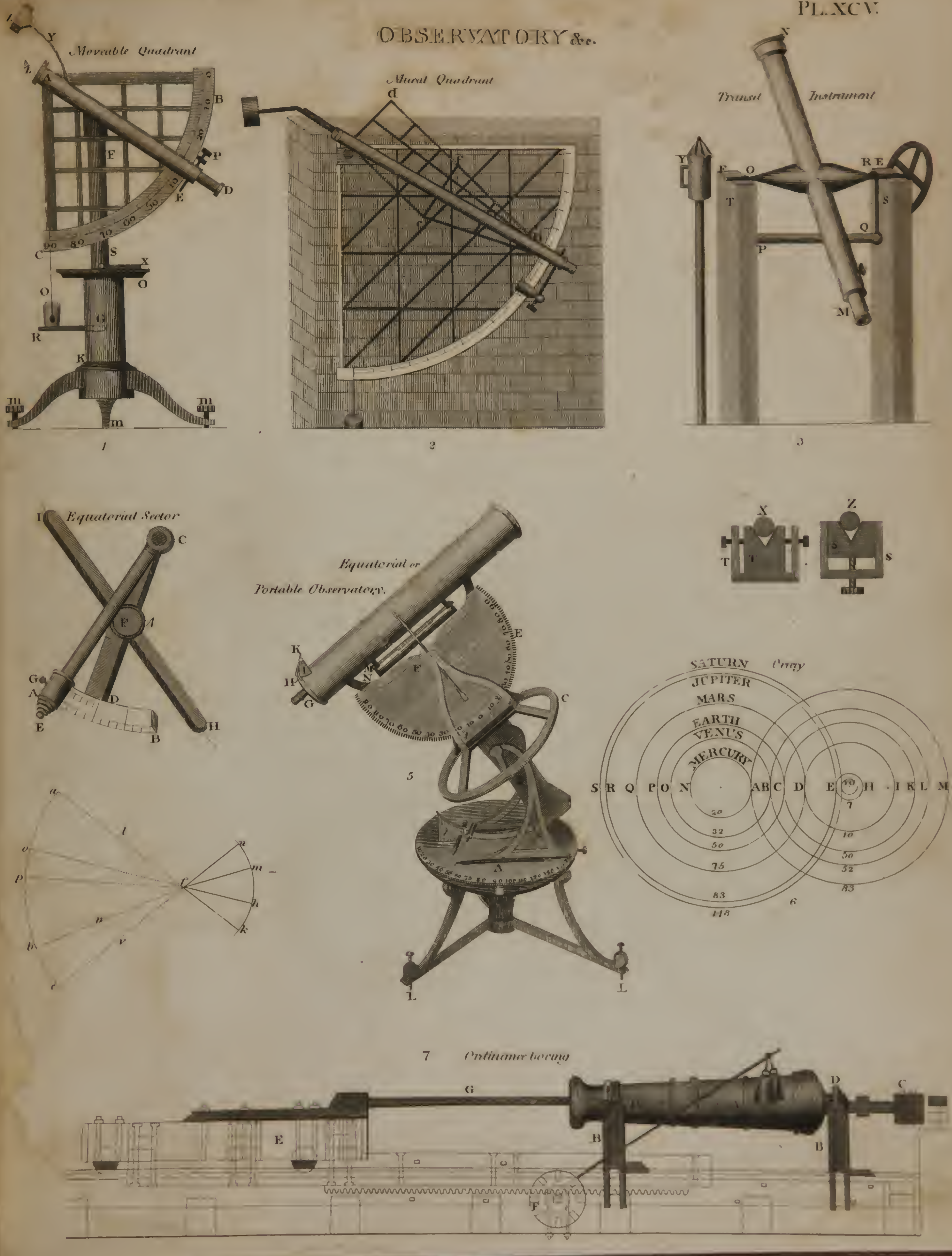

Bark Mill
Indigo Mill
Mr. Rawlinson's Colour Mill
Tary's Mill


Diamond
1
2
Zircon
3
Hyacinth
4
Chrysoberyll
5
Chrysolite
6
Garnet
7
Sapphire
8
Precious Beryl
9
Tourmaline
10
Thumerstone
11
Rock Crystal
12
Foliated Zeolite
13
14
Felspar
15
Mica
16
Basaltic Hornblende
17
Calc Spar
18
19
Appatite
20
Asparagus Stone
21
Boracite
22
Fluor Spar
23
Selenite
24
Straight Lamellar Heavy Spar
25
Prismatic Heavy Spar
26
Celestine
27

MISCELLANIES.



OBSERVATORY &c.



OPTICS.

Pl. XC

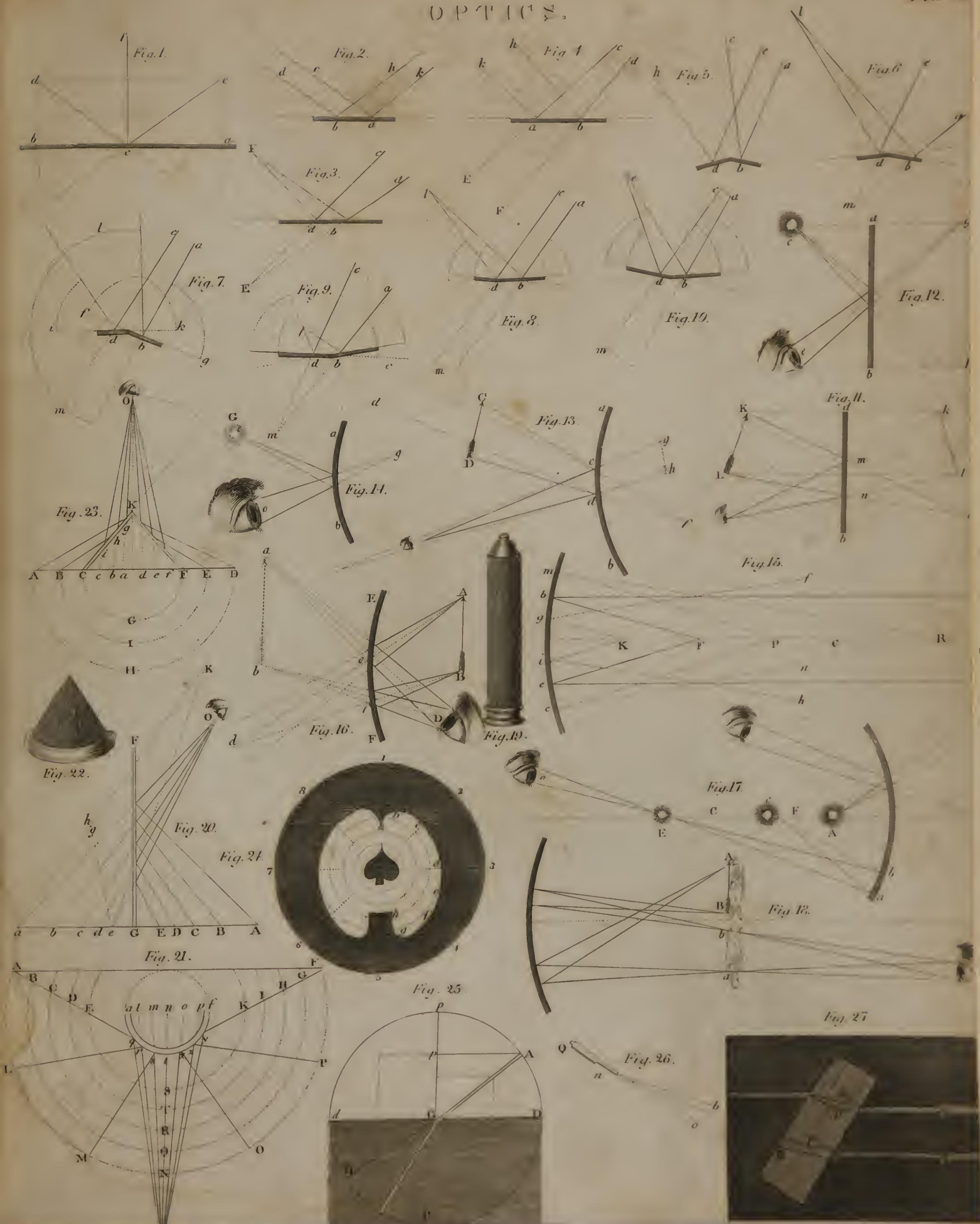
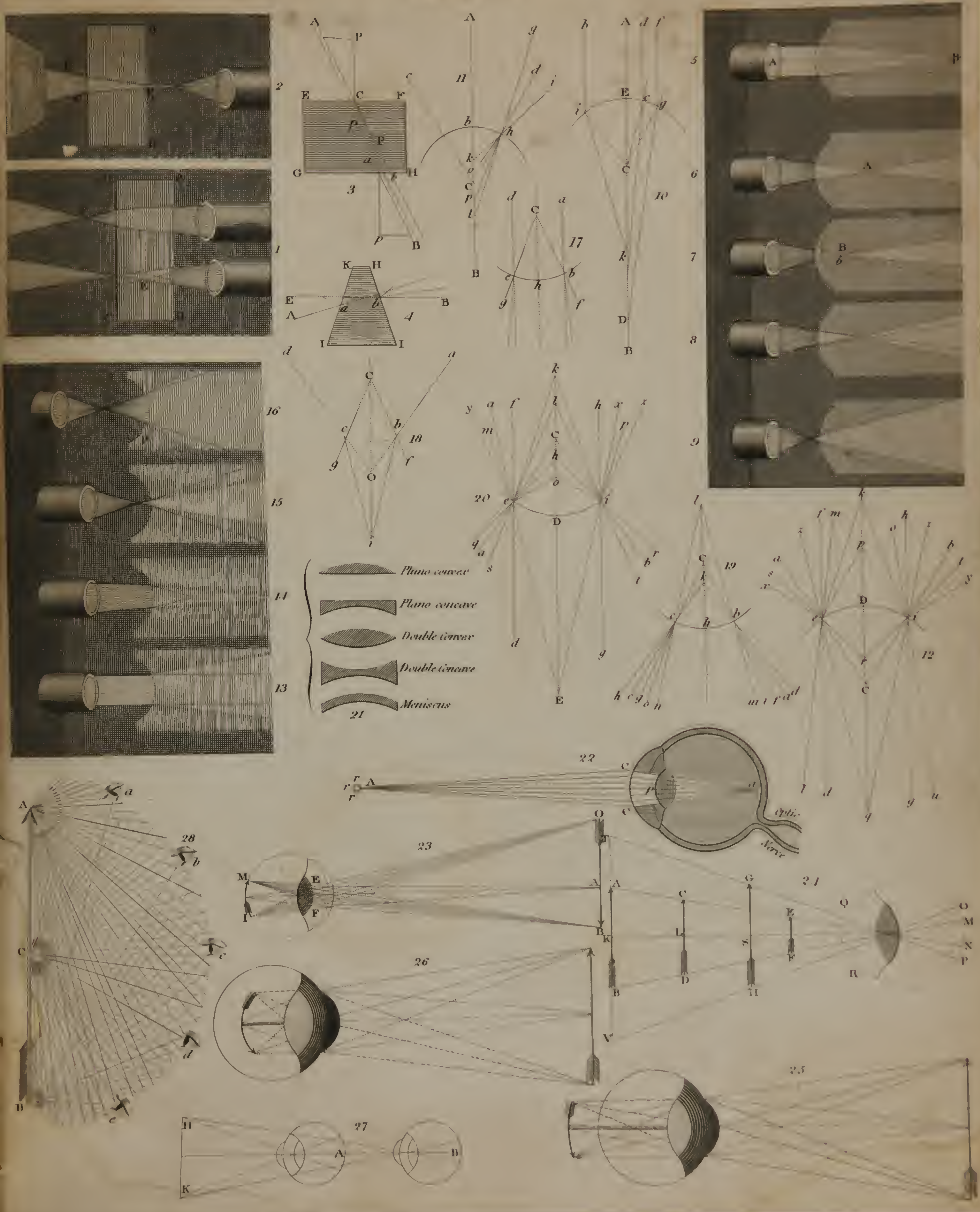


Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4
Fig. 5.
Fig. 6.
Fig. 7.
Fig. 8.
Fig. 9.
Fig. 10.
Fig. 11.
Fig. 12.
Fig. 13.
Fig. 14.
Fig. 15.
Fig. 16.
Fig. 17.
Fig. 18.
Fig. 19.
Fig. 20.
Fig. 21.
Fig. 22.
Fig. 23.
Fig. 24.
Fig. 25
Fig. 26.
Fig. 27


Plano convex
Plano concave
Double convex
Double concave
Meniscus
Optic
Nerve


Magic Lanthorn
Camera Obscura
Violet
Indigo
Blue
Green
Yellow
Orange
Red